Blended Learning Research Trends in Biology Education: A Systematic Review of Literature from 2016 to 2022

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Abstract. The problems of face-to-face meetings in Biology classrooms are the lack of flexibility and materials that cannot be accessed anytime and anywhere. Therefore, it needs to be combined with online learning or called blended learning. The purpose of this review is to describe the implementation of online and blended learning in the context of Biology education in research published from 2016 to 2022. The method used is a literature study of 23 articles by searching databases such as ERIC, Google Scholar, Scopus, and Emerald. The results of the analysis are then synthesized into several themes. Research themes regarding blended learning of Biology education in the last 5 years can be categorized into 4 themes including the effectiveness (61%), challenges of implementation (43%), strategies (61%), and perceptions (48%). Most of the article state that blended learning is effectively applied, but it also has challenges or obstacles. The strategies used in the implementation of blended learning are the use of quizzes, reflection, the use of interesting videos and pictures in the LMS, increasing student interest in online learning, and implementing feedback from the teacher to the student's work. Teachers and students have both positive and negative perceptions of various aspects of blended learning. The recommendation is that there is a need for further research on blended learning in various contexts, for example in developing countries because most of the research has been carried out in developed countries.

Keywords: Biology Education · Blended Learning · Systematic Review

1 Introduction

The implementation of face-to-face learning in Biology classes has several issues for the implementation, for example in Biology learning in various contexts such as anatomy, physiology, and biochemistry, including lack of flexibility [1, 2], materials that cannot be accessed anytime and anywhere [3, 4], the large number of students so that they cannot accommodate practicum activities [5, 6]. The solution to this issue is combining face-to-face learning with online-based learning, or blended learning. Blended Learning is a learning model that combines face-to-face with online-based learning using technology accessed online and offline [7]. E-learning and multimedia technologies are used, such

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as video streaming, virtual classes, and online animated texts combined with traditional forms of learning in the classroom. Blended learning has become popular and widely used during the Covid-19 pandemic as face-to-face education in schools was stopped in many countries to prevent the spread of Covid-19 [8].

Blended learning strategies have been widely used in various contexts or subjects, both at the high school and college levels. The review of current trend of Blended learning is important to be conducted to know the implementation, the effectiveness, the challenges and the strategy of implementation. Several reviews of blended learning have been conducted by some previous research, for example [9] conducted a review and found 4 obstacles in the implementation of blended learning in terms of combining flexibility, stimulating interaction, facilitating the student learning process, and fostering an effective learning climate. In addition, [10] also reviewed the implementation of blended learning in universities and [11] reviewed the factors that influence the successful implementation of blended learning that can improve student achievement. However, the review conducted is still in a general context or not domain specific in Biology education context. Although there are also some reviews that are in specific domains, they are not yet specific to the context of biology. The review of the implementation of blended learning in the context of biology education is still very limited in the literature. The purpose of this review is to describe the implementation of blended learning in the context of Biology education in research published from 2016 to 2022.

2 Method

Document search is conducted manually by searching for journals that are related to Blended Learning in Biology. First, some keywords or key terms are used to search the literature in an electronic database. Keywords for database search are blended learning, flipped learning, and biology, with some modifications using “AND” and “OR”. Four criteria are applied to determine which studies will be reviewed including the journal, subject, year of publication, and language. First, the year of publication in this study is only research published in the last six years from 2016 to 2022. Second, the database for journal article searches only includes Google Scholar, ERIC, and Scopus. Other databases such as A+ Education, ISI Web of Science, and IEEE libraries are excluded. Third, research must be an original article and peer-reviewed and directly related to the research topic. Fourth, the subject of the study being studied must be biology and the branch of study, so other contexts such as physics, chemistry, or general science are excluded. Finally, the included study language must be English, but not limited to any country.

After some potential articles are identified, the screening process is focused on titles and abstracts. Based on the initial search, 305 articles on Google Scholar and 432 potential journal articles were found on ERIC and 232 and Scopus respectively. The final analysis that is included in this research is 23 articles in total. Then, we do an analysis by identification of the main characteristics of the study, and research themes, including year of publication, countries, and participants. The themes are related to the effectiveness, challenges of implementation, strategies, and perceptions. The year of study is counted how many publications each year from 2016 to 2022, and the participants are

grouped into High School and University students. Data were extracted by analysing each article and then grouping the findings into general themes by analysing research topics by coding and grouping research that has similar topics. The research theme is identified by using the author's explanation in terms of the objectives and focus of the research and research discussion. Then, the data is presented in a table with Microsoft Word. The data were analysed qualitatively descriptively by comparing the data in each category.

3 Results and Discussion

3.1 The Characteristics of the Reviewed Studies

Our results showed that the blended learning research is conducted on several continents, including 11 out of 23 of the research in Asia (China, India, Turkey, Korea, Indonesia, Philippines), and the others in Australia, Europe (Montenegro, Greece, Norway), Africa (South Africa, Namibia), and North America (USA, Canada) (Table 1). Most of the research is published in 2016 (22%) and 2021 (17%). According to the participants, most of the studies used university students, which is 17 out of 23 or 74%, and only 4 studies (17%) were high school students and 7% were teachers. The context of Biology that is used in the study is mostly anatomy (33%), and other studies are in the context of molecular biology, physiology, biotechnology, laboratory technique, general biology, genetics, and biosciences.

3.2 The Emerging Themes of the Reviewed Studies

We found that the current trend of Blended Learning research in Biology education mostly discusses four themes including the effectiveness (61%), challenges of implementation (43%), strategies (61%), and perceptions (48%). The result of the analysis of reviewed studies is shown in Table 1.

3.2.1 The Effectiveness of the Implementation of Blended Learning in Biology Learning

Blended learning is effective for improving student achievement in secondary schools and college students. Blended learning improves student academic achievement in several subjects such as anatomy [3, 4, 12], molecular biology [1, 20], physiology [2], biotechnology [5], laboratory technique [6] and biosciences [13], tissue culture [21], genetics [27]. In the anatomy course, [3] integrating online learning using LMS and learning videos as a complement to face-to-face learning has improved medical student learning outcomes [12, 13], and science process skills [21]. The reason for the effectiveness of BL in this study is because: Online videos allow demonstrations with direct methods that are difficult to convey through lectures. Anatomy courses require an understanding of 3-dimensional structures and biomolecular relationships. The strategy is the use of cadavers but sometimes because of the large number of students and the existing model is incomplete or detailed. This effect also occurs because of the flexibility for students to be able to study anywhere and anytime. The effectiveness of blended

learning has also been proven in other studies on human anatomy courses during the Covid-19 pandemic in Korea [12] and in bioscience courses including anatomy, physiology, and biochemistry [13]. Blended learning also improve students' understanding of Genetics concepts [27]. This is because students can integrate the knowledge gained from teaching materials in LMS according to the speed of learning and can learn anytime and anywhere (more flexible). Flexible learning improves students' interest in learning because it is related to metacognition and affects knowledge and learning independence. Online Assessment in the form of Multiple Choice at LMS and the value that appears immediately after working makes students get instant feedback. Third, students feel an increase in learning motivation, interest, and satisfaction in learning [22]. Students have a deeper understanding of the learning content. This effectiveness is because students who are taught using the blended learning method feel they have a better understanding and a higher level of satisfaction than only face-to-face students [22]. Students also perceive that this strategy is more efficient and saves time and low costs even though face-to-face hours are reduced but students can still study independently [13].

In addition, Blended learning is not only effectively applied to the lecturing session, but also to biology practice by the application of virtual laboratories (computer simulation-based laboratories). [1] stated that the experimental section in a virtual lab in e-learning molecular biology courses is very important to understand molecular biology knowledge. This is also supported by [5] that a Virtual lab is effectively applied in blended learning because it can help integrate theory and experiment so that students understand better. Virtual labs make it possible to practice without the help of a teacher and they can reduce mistakes when conducting experiments in a real lab. Interactive sessions in the virtual lab help improve lab skills because the procedure is explained in detail and can be repeated when students do not understand the procedure so that students feel like they are in a real lab and can be accessed anywhere and anytime. Blended Learning which is integrated with Virtual Lab also improves student performance in terms of their pre-test and post-test scores. [6] compared learning outcomes and attitudes and costs of 3 different learning designs between Physical labs (PL), Virtual labs (VL-A) and Hybrid Flipped labs (VL-H). There are significant differences between student course grades in 3 different lab designs or formats. VLH students had higher course grades than PL and VLA and had more positive attitudes towards biology. The use of a Virtual lab has a lower cost when viewed from a cost analysis. A real lab is still needed to complete the VL because it serves to provide students with real experience with lab tools, remove misunderstandings and make students have a positive appreciation of science process skills. Behaviour change plays a very important role in scientific inquiry. The low grades of VLA students are a warning that implementing a virtual lab without teacher support will have poor results. Virtual lab needs to be developed further to provide information on what should be developed.

Besides improving academic learning outcomes, blended learning is also effective in increasing positive attitudes [15], and student creativity [14, 15] found blended learning to be effective in increasing social attitudes and caring for the environment. Students can appreciate classmates by having group discussions in zoom media and online discussion forums. There is a positive correlation between learning achievement in blended learning

with environmental care and social attitudes. The teacher believes that the blended learning strategy can develop students' interest in learning science because blended learning combines technology and interaction to produce students' social knowledge.

In addition, [14] found that students' creative thinking abilities increased based on the pre-test and post-test N-gain scores. This is because the learning process has a stimulus and the influence of project assignments in google classrooms that are used so that the information/material provided can be easily accessed including assignments and questions. The category of creative thinking is fluent thinking with an N-gain value of 0.7 means that the ability to think creatively is very high seen from the ability to analyse writing literature and relate the existing literature. However, the control group is in the elaborative thinking category because they are only passive listeners during learning, so they are less able to develop their creativity. The use of LMS also makes learning time-saving and easy to collect so that lecturers can easily post comments on student assignments and provide feedback quickly. However, in another study, it was found that traditional learning is more effective than blended or full online learning in anatomy courses [4]. These findings are different from those found by other researchers [3, 4, 12]. The traditional method of face-to-face lectures remains the most preferred and effective teaching modality according to students compared to blended or fully online learning. The greater satisfaction for anatomy education with traditional methods can be attributed to the fact that students are more familiar with traditional lectures and may feel more isolated in a virtual learning environment without eye contact with the teacher. Regarding gender differences, male students have a higher average score than women in the strategy, in terms of self-regulated learning female students are better at learning [12]. In contrast to the result of other research, [20] found that blended learning does not change students' performances to answer short answers and multiple choices compared to non-blended learning. [26] also found that assignment scores did not differ between blended and traditional laboratories. In the next section, we will review the challenges or obstacles in the implementation of blended learning.

3.2.2 Challenges and Obstacles in Implementing Blended Learning in Biology

The implementation of blended learning has several challenges or obstacles faced by teachers and students. The first challenge is the preparation for the implementation of blended learning which has many issues, so its implementation is not optimal. [3] stated that the transition process from traditional to online learning is a challenge because of the lack of readiness and online learning designs that have not been maximized to enable students to understand the material provided. The second challenge is the lack of communication between tutors and students. [8] found a negative view of teachers, such as teachers feeling less communicating with students, and are less able to make some students continue to participate in online learning so as not to be left behind by other students. The third challenge is the lack of competence of teachers so that blended learning does not run optimally. Teachers also experienced problems due to a lack of competence in using technology due to a lack of training from schools. Literacy using computers and modern apps is also an inhibiting factor. For example, [5] found that there were students who had difficulty operating VL due to a lack of computer literacy. The fourth challenge is due to technical constraints such as the internet network. For

Table 1. The emerging themes of the reviewed studies

Article	Year	Country	Participants	The emerging themes of reviewed studies			
				The effectiveness	The challenges	The strategy to implement	The perception
[1]	2021	China	Univ. Students	√		√	√
[2]	2018	Montenegro	Univ. Students		√	√	√
[3]	2016	Australia	Univ. Students	√	√	√	√
[4]	2021	Greece	Univ. Students	√			√
[5]	2015	India	HS Students	√	√	√	
[6]	2016	USA	Univ. Students	√			
[8]	2020	Turkey	Teachers		√		√
[12]	2021	Korea	Univ. Students	√	√		√
[13]	2021	Norway	Univ. Students	√	√	√	
[14]	2020	Indonesia	Teacher	√	√		
[15]	2016	India	HS Students	√			√
[16]	2015	Turkey	Univ. Students		√	√	
[17]	2018	Turkey	Univ. Students		√	√	
[18]	2021	South Africa	Univ. Students			√	
[19]	2017	USA	Univ. Students			√	√
[20]	2022	Canada	Univ. Students	√		√	√
[21]	2019	Indonesia	Univ. Students	√		√	
[22]	2016	Turkey	Univ. Students	√			

(*continued*)

Table 1. (*continued*)

Article	Year	Country	Participants	The emerging themes of reviewed studies			
				The effectiveness	The challenges	The strategy to implement	The perception
[23]	2018	Indonesia	HS Students			√	
[24]	2022	South Africa	Univ. Students		√	√	
[25]	2022	Namibia	Univ. Students			√	
[26]	2016	USA	Univ. Students	√			√
[27]	2017	Philippines	HS Students	√			√
Total (%)				14 (61%)	10 (43%)	14 (61%)	11 (48%)

example [16] found that some students had problems with the internet network, so they were unable to follow the lesson well. This is also found in other studies [12–14, 17]. These network constraints cause many students and students to have difficulty accessing learning resources and not all students can participate or attend class. The recommendation is that the material should be accessed offline. Although in another study it was found that most students did not experience network problems [2].

The next challenge is that LMS which is used as a complement in blended learning is less able to improve communication between students and teachers or tutors. Moodle does not improve communication with tutors and fellow students so it is necessary to redesign the chat form so that it can be as popular as Facebook or WhatsApp [2]. [8] also found a lack of group interaction or students were unable to work in groups well even though there were already applications that facilitate collaboration such as Google Docs, google slides, zoom meetings and others. [12] also, see that this interaction is still less active in LMS. Another obstacle is the learning content in the LMS. [16] found that sometimes students cannot understand the videos in the LMS. For example, the surgical videos are not clear, the number of videos is limited, the images are not detailed, and the video animation is too slow. So, it is necessary to control the quality of the content. The main challenges of blended learning in anatomy courses are the high cost of cadavers and limited qualified instructors [24]. The last obstacle faced by teachers in learning is the possibility of plagiarism by students when doing assignments or exams. For example, [17] found that students have the potential to commit plagiarism when discussing in LMS or when completing tasks that affect learning outcomes. This is because the teacher cannot supervise optimally during exams as well as face-to-face, although this can be overcome with Turnitin Software. In the next section, we will review the strategies used in the implementation of blended learning.

3.2.3 Strategy for Implementing Blended Learning in Biology

Teachers and lecturers use a variety of different strategies in the implementation of blended learning. [17] state that the use of different designs will have different learning outcomes. He recommends considering instructional strategies in blended learning. There was a significant difference between the academic scores based on the instructional strategies given to the different groups. First, the strategy used is using the LMS platform (Learning Management System in the form of Moodle. Several studies have proven the effectiveness of using Moodle. [2] found that Moodle improves communication with tutors. Lecturers can also monitor student activity more efficiently and provide faster feedback. Although Moodle can be effectively used for blended learning, Students who accessed Moodle with moderate frequency had higher formative test scores than those who frequently accessed Moodle. The proportion of comparisons between face-to-face and online learning will affect student attendance in class. Students who were very dependent on the Moodle LMS had higher attendance rates in the LMS than students who had a greater proportion of face-to-face classes. This is also supported by [3] who also use the Moodle LMS in anatomy learning for medical students. Lecturers can upload a variety of varied teaching materials such as online content, recording lectures, as well as class discussions. However, what needs to be considered during the transition from full offline to fully online, there are many things that must be considered. In addition, the strategy that needs to be considered is the features in the LMS used. Some features are accessed more often than others. For example, the study of [2] found the feature that students most frequently accessed was lecture notes, although other features were also accessed. In addition, what features in the LMS should students develop and like to make the LMS more attractive? [16] suggested that the content in the LMS should be more complete in terms of content and quality.

Another method that needs to be used is a more innovative and interesting assessment. [1] recommend using the quiz after the lecture method. Eighty per cent of respondents argue that the post-lecture quiz was very helpful or helpful for their studies. [18] found that quizzes and Tutorials are the most effective learning strategies with the highest effect size on test results. In addition, the use of videos and images in the LMS needs to be used to visualize abstract concepts. [16] suggested the use of video in histology material (animal tissue) because animal tissues are invisible. But what must be considered are strategies to monitor whether students view videos before teaching and effectively link video content into classroom teaching. Communication should also be improved between tutors and students. In terms of content, students find the content helpful because they can replay when they do not understand. But the content needs to be constantly updated. Another strategy that needs to be done is that teachers need to increase students' interest in learning. [18] found that test score performance is the strongest predictor of student participation and tutorial performance. Participation during the Tutorial is the most powerful predictor of success on the exam. Student's willingness to learn in the classroom is positively correlated with learning success. Students who read the online material given before face-to-face lectures tend to have a better understanding.

In addition to the theory class, in the practical class, there are also several strategies that can be implemented. [5] using the Virtual lab suggests that the virtual lab should be used before the implementation of the real practicum. Students in the blended

learning group tend to have better performance than those who only use the virtual lab, so VL should be used before practicum in the real lab. The use of learning reflection also needs to be considered by the tutor. [17] compares students who are taught with various strategies, for example with Discussion Questions, Task assignments, quizzes, and Reflection Paper. Students who are taught with quizzes every 3 weeks and reflection papers have higher scores. In addition, using the Reflection paper Application used in Blended Learning can increase learning motivation because it makes learning more entertaining, interesting, and useful. Students can also reflect on what they have learned, why it is useful and what is done to understand it. The use of feedback is also an important strategy to implement. Students think that the feedback given is very important, especially qualitative feedback in the form of comments from tutors on their assignments so that they are not only related to numerical or quantitative scores [17]. [19] recommends the importance of self-directed learning skills in blended learning. He found that students who used self-study strategies tended to have higher academic scores than students who did not. They will be more comfortable collaborating and discussing during face-to-face sessions if students have prior knowledge of the topics discussed through shared materials or videos. Self-regulated learning is needed by students, especially in interpreting difficult material [13]. During developing modules, [20] suggested that the module should be concise (not too long), it is divided into sub-section with clear instructions and be more interesting. It should also be completed with videos, animations, pictures, games, and flash [21], for example, by developing learning media and interactive assessment as the content [23, 24]. The learning media in LMS should be completed with a clear illustration of content, immersive 3D animation and quizzes [24]. [25] also supported that three technology integration strategies for enhanced student engagement in the blended learning environment are keeping the learning social, keeping the learning authentic, and ensuring that the technology adds value to learning.

3.2.4 Teacher and Student Perceptions Towards Blended Learning in Biology

Perceptions in the implementation of blended learning found in the literature mostly discuss the perceptions of students and teachers. First, regarding teacher perceptions, there are teachers who have positive perceptions or views, and some are negative about the use of blended learning in Biology learning. For example, [8] who examined several Biology teachers in Turkey found that there were Biology teachers in Turkey who had a positive view but there were also those who had a negative view of the implementation of online meetings during the Covid-19 Pandemic. This view can be classified into classroom management, competence and teaching and learning process, and distance learning process. First, in terms of classroom management, Biology teachers have a positive view of time management, classroom control and a more flexible learning process. Second, in terms of competence and the teaching and learning process, biology teachers have a positive view in terms of the use of new technology, using learning technology more intensely, more flexibly, and more and more online content or materials being developed. Third, in the distance learning process, biology teachers have a positive view because learning becomes more continuous and flexible where the material that the teacher provides in the LMS can be accessed at any time by students and saves time, for example, teachers

can send screen recordings and students can play back when they do not understand. Teachers are also more efficient because they don't need transportation to school.

Second, regarding student perceptions, research references also state that students have both positive and negative attitudes. Perceptions about the use of Moodle in blended learning, [2] found that students agree that Moodle is only used to complement traditional methods and less than a half agree that LMS can completely replace traditional methods. Likewise, [3] found that students have a positive view of blended learning being used to support surgical practice in the laboratory. Students prefer live lectures compared to online resources provided because of the explanation from the lecturer, not only the material. A positive view also occurs because they feel that online resources can be studied in a more flexible time. [1] also found that most respondents showed a positive attitude towards the teaching method of molecular biology courses using Blended Learning. Meanwhile, the results of the blended learning survey showed that most students considered that the effect of teaching in class was better than full online teaching. [16] also found that students have a positive view of blended learning strategies in anatomy learning in terms of visuality, content, effective learning, expectations of learning, accessibility, motivation, and continuity. Students have a positive view of useful content, make learning easier, can fulfil their desires and increase motivation. In terms of effective learning design, students have positive attitudes because it makes learning easy, and the content given before learning helps in preparation before class. Regarding accessibility, students can access materials anywhere and anytime. Blended Learning also increases learning motivation because of the chat feature. [12] found that most students who participated in the survey preferred online lectures because they saved more time during online classes, and they used them for self-study, with video recordings of lectures being repeated. Meanwhile, students who prefer face-to-face lectures argue that they can concentrate more than online lectures and have better accessibility to ask questions to the teacher. [26] also found that some of the students' favourite aspects of the blended laboratories included "knowing what to expect" and "more efficient use of class time," whereas some of their least favourite aspects included "videos seemed redundant" and "not being able to ask questions." [27] also argue that Blended Learning courage the students to make use of computers in learning, a practice that will reinforce students' positive attitude towards computers and promote computer self-efficacy.

In addition to positive views, the literature also found negative views. [3] found that students had a negative perception of the assessment used in blended learning. The format should be more practice and preferably more feedback and too much content. They give a lot of negative comments on online discussion forums that still need to be improved, while online materials also many students complain because they are confused about when to solve them and where to find them. Students have a negative perception if the material in the LMS is incomplete, or the material uploaded by the lecturer is less related to the competencies that must be achieved so the author suggests that there be Quality control of the content to be provided online at LMS. Third, regarding the perception of high school students, [15] found that students have positive perceptions of blended learning designed by teachers with technology integration so that it is not boring to listen to in class. [19] states that positive or negative student perceptions of the online learning component will affect their independent learning ability. There is a positive correlation

between how students perceive learning videos and how often students watch them before face-to-face learning. Students have a positive view of the active learning aspect used in flipped learning but less positive in terms of the online lecture component. [4] found that most students perceived that distance teaching could not completely replace traditional anatomy teaching methods. The transition from traditional teaching methods to distance methods seems to affect students' performance in exams. [20] also found that students tend to have a negative attitude because it does not improve students' critical thinking skills and inquiry.

4 Conclusion

Research themes regarding blended learning of Biology education in the last 5 years can be categorized into 4 themes including the effectiveness (61%), challenges of implementation (43%), strategies (61%), and perceptions (48%). The effectiveness of blended learning can be classified into theory classes or practical or experimental classes. Most articles stated that blended learning was effectively applied. But it also has challenges or obstacles that need to be considered such as internet connection, lack of teacher skills in using technology, lack of preparation during the transition from face-to-face to online, and incomplete material in the Learning Management System (LMS) used. The strategies used in the implementation of blended learning are the use of quizzes, reflection, the use of interesting videos and pictures in the LMS, increasing student interest in online learning, and implementing feedback from the teacher to the student's work. Then regarding perceptions, it can be found that teachers, students, and students have positive and negative perceptions of various aspects of blended learning.

The recommendation is that the blended learning strategy can be effectively applied in Biology learning, but it is necessary to consider the challenges that will be faced so that learning becomes more effective. In addition, teachers or tutors need to pay attention to strategies so that in Biology learning the implementation of blended learning can run more effectively in future research. There is a need for further research on strategies, effectiveness, challenges, and perceptions of blended learning in various contexts, for example in developing countries because most of the research has been conducted in developed countries. Further research should also use high school students and teachers since most of the current research used University students as their participants.

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