Jurnal Kependidikan:
Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran
https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index

Vol. 8, No. 1 : March 2022
E-ISSN: 2442-7667
pp. 162-169
Email: jklppm@undikma.ac.id

Effect Size of Blended Learning Model in Improving Students' Science Competence

Mega Elvianasti[1], Festiyed[2], Asrizal[3], Desnita[4], Rosi Feirina Ritonga[5*]
[1,5*]Biology Education, Universitas Muhammadiyah Prof. Dr. Hamka, Jakarta, Indonesia
[2,3,4]Science Education, Universitas Negeri Padang, Indonesia
***Corresponding Author. Email: rosiritonga@uhamka.ac.id**

Abstract: This study aims to measure the effect size of experimental research that focuses on the application of the blended learning model in science learning and measures students' scientific competence. The method in this study used a meta-analysis technique with a quantitative approach. We found 11 articles that matched the criteria with a range of 2015-2021 publication years from SINTA accredited national journals and reputable international journals. The data tabulation sheet was used as a research instrument containing criteria in the form of experimental and control groups by containing information on the number of samples, average, standard deviation, education level, country, type of control, and students' science skills. The data were analyzed using the openMEE application and it obtained a summary effect size of 0.861 so that it can be interpreted as being in the high category and it is assumed that blended learning is effective in improving students' science skills in the form of conceptual understanding, science process skills, critical thinking, and others. Blended learning can be recommended as learning that has the potential to be implemented in the current digital era and can be a reference for further researchers to develop blended learning models in science learning.

Article History
Received: 24-11-2021
Revised: 19-01-2022
Accepted: 29-01-2022
Published: 09-03-2022

Key Words:
Effect Size, Blended Learning, Science Competence.

How to Cite: Elvianasti, M., Festiyed, F., Asrizal, A., Desnita, D., & Ritonga, R. (2022). Effect Size of Blended Learning Model in Improving Students' Science Competence. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *8*(1), 162-169. doi:https://doi.org/10.33394/jk.v8i1.4449

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Introduction

The era of the industrial revolution 4.0 was marked by progress in the use of technology, information, and communication (ICT) in learning. Teachers and students are required to be able to master ICT to optimize learning. Many problems arise in learning in the digital era as it is today, including the unideal use of digital platforms to support successful learning and dependence on the availability of information technology in the form of internet access and technological devices (Singh & Thurman 2019; Adedoyin & Soykan 2020; (Sultoni et al., 2021). On the other hand, Sultoni et al., (2021) argue that problems in the form of online learning competencies, student attitudes, learning tools, and attitudes of parents need to get attention from various parties. In developed countries, traditional science learning (face to face) has begun to shift to digital learning by utilizing online and mixed platforms, in Indonesia alone this learning model has become a trend since the learning process is carried out remotely due to the Covid-19 outbreak.

During the Covid-19 pandemic, distance learning was implemented almost all over the world. Educational programs are shifted to virtual classrooms and independent e-learning, although face-to-face learning is implemented, the mixed learning trend will continue (Kelly, 2020). After Covid-19, learning in schools has not been fully face-to-face because it is still in the pilot stage, for that it is necessary to develop a learning model that can be a solution. One of the learning models that can be applied post-Covid-19 is blended learning. This learning model combines synchronous and asynchronous face-to-face activities. According to Hoic-

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Vol. 8, No. 1 : March 2022
E-ISSN: 2442-7667
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Bozic et al., (2016) model definition, blended learning means combining traditional learning with supportive learning technology. While the concept of blended learning quality (Hrastinski, 2019) emphasized that quality needs to be improved by utilizing the integration of face-to-face and online learning. Blended learning develops very rapidly, especially in the academic field, this is one of the contemporary educational trends (Hubackova & Semradova, 2016) and will emerge as the dominant learning model in the future.

Learning to use blended learning can improve access to learning for most groups of students and their beliefs about how effective the learning environment is (Dziuban et al., 2018). Stein & Graham, (n.d.) recommend blended learning as a mix of physical and online activities and experiences. This benefits students, teachers, and administration in increasing access and convenience, learning can be improved and costs are flexible. According to Movahedzadeh (2011), the advantages of Bended Learning compared to fully online learning or face-to-face learning are that students who have difficulty socializing in face-to-face learning will perform better, contribute and increase their self-confidence and performance. When designing Blended Learning, the concepts that need to be considered are mixing synchronous and asynchronous interactions, planning learning time, and accuracy in combining technology. According to Peddibhotla (2016), asynchronous forums are commonly used in online learning in general and describe methods for conducting discussions.

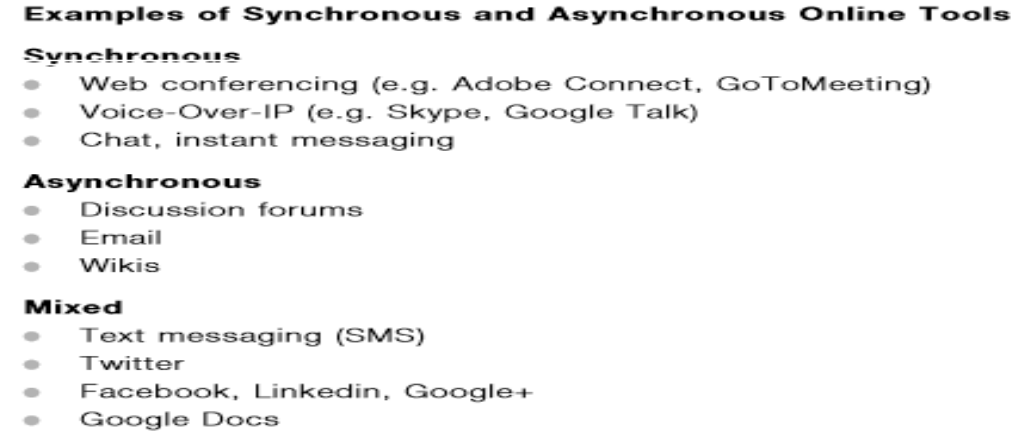

Figure 1. Examples of Synchronous and Asynchronous Online Media

Clayton & B (2012) categorize that there are four BL models in the K-12 sector, namely: 1) Rotation model, the modality that belongs to the class that is full-learning, group projects, and individual tutoring. 2) The flex model, where content is delivered online and students move according to a schedule. 3) The self-blend model, where students take one or more online classes to complement conventional classes. 4) Virtual model, where students divide their time between distance learning in an online setting.

Meta-analytical research has contributed a lot to current knowledge (Mikolajewicz & Komarova, 2019), especially in education. This study aims to measure the effect size of articles on experimental research results by tabulating data in the form of the average and standard deviation of each experimental group and control group so that it can describe the extent of the blended learning model that has an impact on science learning.

Research Method

The research method was a meta-analysis using a quantitative approach. According to Wood & Eagly (2009), meta-analysis aims to summarize quantitative data from several studies to make findings of what we will explore in a particular area. In the use of meta-

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E-ISSN: 2442-7667
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analysis, researchers can synthesize quantitative results from relevant study samples and generalize them to a problem.

The systematic review and data collection techniques of this study consisted of three steps referring to Pigott & Polanin (2020) namely: 1) searching and collecting similar literature, 2) abstracting, screening, and analyzing the completeness of documents, and 3) coding the studies that have been collected. The study was conducted on eleven articles in national and international journals in the 2016-2021 publication range. The articles selected for meta-analysis are articles that use experimental research methods (consisting of the experimental group and control group) and contain the effectiveness of learning using the *blended learning* model which can measure students' science competence at the Elementary School, Junior High School, Senior High School, and Higher Education levels. The instrument used is a data tabulation sheet that is filled in for each article, then the data is analyzed using openMEE software that can calculate the effect size (ES) of each article and calculate *mean* (ES) and analyze the ES subgroups of known data. After getting the effect size then it is categorized based on the following table:

Table 1. Category of Effect Size (Cohen, 1981)

No.	ES	Category
1	0.00 ES 0.20	Ignore
2	0.20 < ES 0.50	Low
3	0.50 < ES 0.80	Moderate
4	0.80 < ES 1.30	High
5	1.30 ES	Very High

Results and Discussion

The results are categorized based on the ES of each article, ES by level, ES by country, ES by type of control, and ES by science skill.

Table 2. Article Code and Category

No.	Article Code	Effect Size	Category
1	M1 (Akhmalia et al., 2018)	1.343	Very High
2	M2 (Harahap et al., 2019)	884	High
3	M3 (Zawawi et al., 2017)	.080	Ignore
4	M4 (Hwang et al., 2019)	0.065	Ignore
5	M5 (Alsalhi et al., 2019)	309	Low
6	M6 (Lin, 2020)	1.375	Very High
7	M7 (Prihadi et al., 2021)	1,653	Very High
8	M8 (Sulisworo et al., 2020)	.591	Ignore
9	M9 1st Study (Akgündüz & Akinoglu, 2017)	,779	Moderate
10	M9 2nd Study (Akgündüz & Akinoglu, 2017)	340	Low
11	M10 1st Study (Seage & Türegün, 2020)	1,429	Very High
12	M10 2nd Study (Seage & Türegün, 2020)	0.926	High
13	M10 3rd Study (Seage & Türegün, 2020)	2,339	Very High
14	M10 4th Study (Seage & Türegün, 2020)	1,479	Very High
15	M11 (Barhoumi, 2016)	538	Moderate
	Average	**861**	**High**

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E-ISSN: 2442-7667
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In table 2, it is obtained the summary effect size of 0.861 with a standard deviation of error of 0.177 and p-value < 0.001 so that it can be interpreted that the impact of the BL model is effective in improving students' science competence. The competencies in question are conceptual understanding, KPS, critical thinking, and others. For the heterogeneity test, tau ^{2} of 0.446 with a p-value <0.001 (significant) so that it can be interpreted that the variance of the 16 studies that have been analyzed is diverse and has the potential for moderating variable analysis.

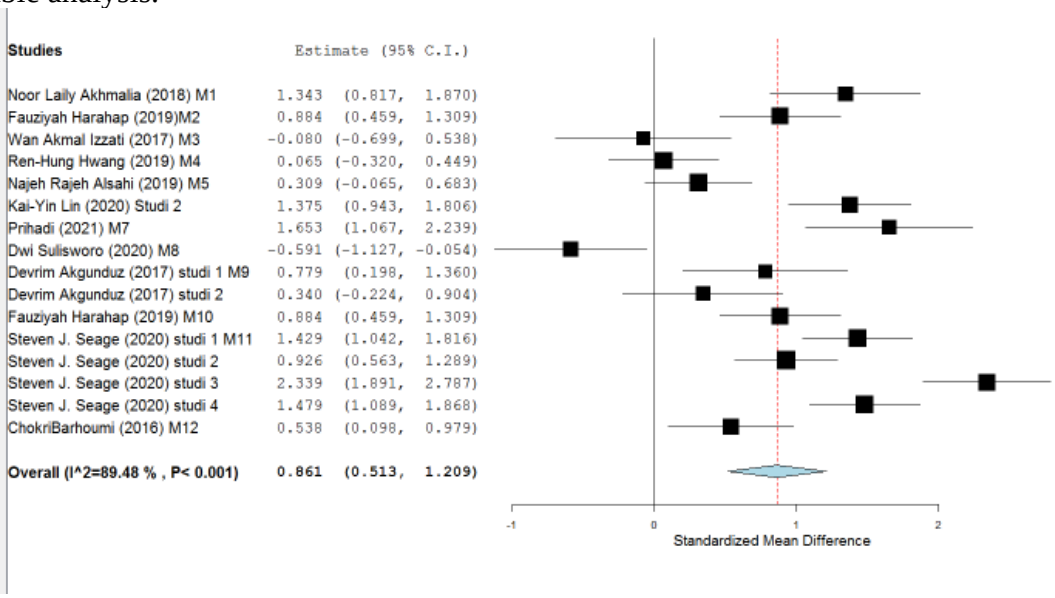

Figure 2. Forrest Plot Effectiveness of Blended Learning in Science Learning

The Forest plot above describes the distribution of effect size For each study, there are two studies on the left side (negative) which shows that the performance for the control group is better than the experimental group. Meanwhile, if the ES is in the right (positive) position, the experimental group's achievement is better than the control group.

The Effectiveness of Blended Learning in Terms of Class Level

Table 3. The Effect size by Grade

Level	Article Code	ES average	Category
Primary school	M4, M11	1.242	Very High
Junior High School	M5, M9	0.569	Moderate
High School	M1, M8,	377	Low
PT	M2, M3, M6, M7, M12	0.883	High

Table 3 above shows that the BL model is effectively used at the Elementary School and Higher Education levels. According to Geçer (2012), BL has a positive effect on elementary and university students. Students state that in BL, they actively participate and make online projects interesting and useful. Moskal et al., (2013) recommends that implementing a successful BL program requires alignment between institution, faculty, and student goals. BL has emerged as a solution to meet the needs and has been widely adopted in various universities (Tshabalala et al., 2014).

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The Effectiveness of Blended Learning in Terms of Implementing Countries

Table 4. Effect size Based on Countries that Implement Blended Learning

Country	Article Code	ES average	Category
Indonesia	M1,M2,M7,M8,M10	833 -	High
Malaysia	M3	.080	Ignore
Taiwan	M4	716	Moderate
Saudi Arabia	M5,M12	423	Low
Turkey	M9	554	Moderate
USA	M11	1.533	Very High

In the state of the United States, namely Florida, Moskal et al., (2013) one existing university has used the BL model for sixteen years and illustrates that with the right support and planning, BL can result in positive institutional transformation (Harris, 2017). For years, technology has become a prominent daily fixture in classrooms across the United States.

The Effectiveness of Blended Learning in Terms of Control Type

Table 5. Effect size by Control Type

Control Type	Article Code	ES average	Category
Conventional	M1,M2,M3,M4, M5, M6,M7 ,M10, M11,M12	1.012	High
More models	M8, M9	0,170	Ignore

Blended learning has advantages compared to conventional classes (Harris, 2017). BL appeals to students and encourages them in deep thinking and caters to different student learning styles thereby enabling students to learn at their own pace. In addition, according to Szadziewska & Kujawski (2017), BL has many advantages such as unrestricted access to the subject matter, increased time effectiveness during class, easier and more efficient communication between teachers and students.

The Effectiveness of Blended Learning in Terms of Students' Science Competence

BL is an emerging paradigm in science education but has not yet been rigorously assessed. Stockwell et al., (2015) found that problem-solving in BL classes could improve test performance, and video assignments increased attendance and satisfaction in science and education communication. Prafitasari (2021) recommends that during the Covid-19 pandemic, creative learning strategies with the BL system are needed so that critical thinking skills can be achieved properly.

Table 6. Effect Size By Skill Category Science

Science Competence	Article Code	ES average	Category
Conceptual	M1, M3	641	Moderate
kps	M2, M10	884	High
Critical thinking	M7,M8	,528	Moderate
Others	M4,M5,M9,M11,M12	0.961	High

Conclusion

This finding has implications for the application of the blended learning model in post Covid-19 science learning. Therefore, it can be a reference to improve students' science skills. Blended learning is a promising learning activity in the digital era and supports the

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development of students' science skills in the 21st century. BL has advantages compared to conventional models because it can facilitate various student learning styles, and help students understand concepts. The Summary Effect size value of 0.861 in this study is categorized as high and can be interpreted as the impact of the blended learning model effectively applied in science learning to improve students' science competence.

Recommendation

The result of effect size measurement can help other researchers in developing a science learning activity using the blended learning model. It is recommended for future research to use other sub-analytical techniques and use a wider range of article sources. For teachers, this research can be a source of reference in developing learning models that are under post-Covid-19 conditions and the demands of the industrial revolution 4.0 era.

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