Asian Journal of Contemporary Education
ISSN(e): 2617-1252
DOI: 10.55493/5052.v7i2.4895
Vol. 7, No. 2, 56-65.

Sustainability of educational technologies: An approach to ratio and feedback

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Article History
Received: 15 August 2023
Revised: 25 September 2023
Accepted: 10 October 2023
Published: 20 October 2023

Keywords
Blended learning
Education
Sustainability
Technology.

ABSTRACT

Blended learning is a driving force behind new pedagogical approaches. While many studies have shown the positive effects of blended learning on the students' learning outcomes, the extent and breadth of its sustainability remains an interesting question, given the rapid evolution and diversification of technology post COVID-19 pandemic. In this study, we examined the ratio of technological interventions in blended learning studies, and their corresponding students' feedback by categorizing 37 compliant articles. With a defined set of inclusion and exclusion criteria, and a clear search strategy, we employed systematic reviews to comprehensively and systematically identify, evaluate, and synthesize relevant evidence to probe on a specific research question. The results advocate the notion of ratio, regardless of its specific percentages, predominantly proffering positive feedback, indicating that the integration of technology is essential for supporting sustainable strategies in teaching and learning approaches. Overall, these findings provide a comprehensive body of high-quality evidence that blended learning has the potential to meritoriously support sustainable education model. It has significant practical significance in addition to its implications for empirical research. Additionally, it produces structured guidelines as a result of its thorough analysis, which may help to accelerate the adoption of blended learning.

Contribution/ Originality: The emergence of the education industry has taken on an important role not simply defined by commercial interests selling products and services to schools, but framed into a much wider concern for genuine innovation. This has led to an inquiry if tech-adoption model such as blended learning is sustainable and has the potential to promote lifelong learning, in particular its distribution of ratio between synchronously conducted physical or face to face sessions versus technologically supported sessions.

1. INTRODUCTION

Digital technologies have a profound impact on economies and societies and are changing the way we work, communicate, engage in social activities. Despite huge investments in Information and Communication Technology (ICT), the vision of transformation in the landscape of educational practices has not yet taken place. This is probably due to the predominant focus on hardware and connectivity, which has precluded equally powerful strategies for increasing teachers' ICT skills, improving teachers' professional development, reforming pedagogies and producing appropriate software and courseware (Liu, Geertshuis, & Grainger, 2020). Innovation happens in environments that

are open to change, and for the past few decades, educational technology researches have grown in various scope. Many factors have contributed to this development, including the tremendous investments in information and communication technologies for online modalities and the recent COVID-19 pandemic, which affected many educational institutions (Mahmud et al., 2021). The familiar conventional teaching and learning activities were promptly suspended to adhere to the new regulations. Educators needed to adapt their lesson plans, activities, projects and assessments within a short period of time in order to meet the new standards (Carolan, Davies, Crookes, McGhee, & Roxburgh, 2020), which necessitate pedagogical adaptations such the deployment of blended modalities to cater to a remote teaching and learning.

Technology-mediated interactions have become central to many educational institutions' co-constructive nature of learning. However, such rapid change brought about new challenges and amplified existing obstacles in current teaching and learning processes (Marinoni, Van't Land, & Jensen, 2020; Mishra, Gupta, & Shree, 2020). Nonetheless, the pushed transition has created opportunities, and innovation happens in environments that are open to change. The emergence of the education industry has taken on an important role not simply defined by commercial interests selling products and services to schools, but framed into a much wider concern for genuine innovation. This has led to an inquiry if tech-adoption model such as blended learning is sustainable and has the potential to promote lifelong learning, in particular its distribution of ratio between synchronously conducted physical or face to face sessions versus technologically supported sessions. Blended learning has gained widespread acceptance in higher education due to its numerous advantages, such as lower tuition, better learning environment, and more effective teaching. Its ability to enhance students' learning engagement and sense of belonging has been identified by prior studies (Bouilheres, Le, McDonald, Nkhoma, & Jandug-Montera, 2020; Fisher, Perényi, & Birdthistle, 2021; He & Zhao, 2020). The adoption of blended learning is likely to be the leading teaching strategy in the next twenty-first century (Poon, 2014; Seage & Türegün, 2020), nonetheless, little is known about its sustainable opportunity, specifically post COVID-19 pandemic. With the key points deliberated, the purpose of the study is to systematically aggregate and quantify the ratio of the interventions in blended learning studies, and the corresponding students' feedback.

2. METHODOLOGY

This study used systematic review as its main method. Systematic reviews comprehensively and systematically identify, evaluate, and synthesize all available evidence to probe on a specific research question (Aromataris & Pearson, 2014). With a defined set of inclusion and exclusion criteria, and a clear and explicit search strategy, the findings of a systematic review are generally considered to be more reliable and trustworthy than those of a single study, as they provide a broad and comprehensive overview of the available evidence. This study focused on identifying best practices in technology-aided learning by examining and screening samples from Google Scholar, reference lists, and various online databases from 2015 to 2019. These databases were selected for their relevance to education and technology, including Wiley Online Library, Taylor & Francis Online, Springer, ERIC, Elsevier, ScienceDirect, ResearchGate, ProQuest, JSTOR, IEEE, Sage Journals, APA PsycNET, CALICO Journal, Penn State University Library, Editlib, IGI Global, anitacrawley.net, ascilite.org.au/ ajet.org.au, and Questia. They were chosen because they exhibited features of educational and technological application.

2.1. Screening Process

The initial search yielded 360 samples where the titles and abstracts were analyzed further per the following initial inclusion criteria: 1) the sample included the blended learning approach as operationalised in this study 2) the sample had a controlled (experimental or quasi-experimental) design, and 3) the sample reported on student achievement or learning outcomes. These keywords adapted from Sitzmann, Kraiger, Stewart, and Wisher (2006), were applied as the inclusion criteria: "blended learning", "control", "treatment" and "dependent measures". At this stage, 251 out of 360 samples were disregarded. All the articles included terms denoting (a) blended, (b) hybrid, and

(c) technological intervention, acknowledged by blended learning literature (Graham, Woodfield, & Harrison, 2013). The terms include "technology", "computer", "webbased instruction", "online", "Internet", "blended learning", "hybrid course", "simulation", "electronic", and, "multimedia". Next, full-text screening was performed for the 109 articles. To ensure quality and relevance, the contents of the articles were further reviewed based on the following criteria: employed technology as treatment or intervention, included distinctive conditions of blended learning, defined an intervention study completed with cogent results, and concisely described the study design, independent variables and dependent variables, and objectively reported on learning outcomes for both treatment and control groups.

2.2. Implementing Method 1and Method 2

The researcher in this study chose to adopt Method 1 and Method 2, which were originally developed by Mahmud (2017), as the analytical tools for examining the collected data. These two methods serve a common purpose: the calculation of ratios, a pivotal aspect of data analysis in this research context.

Method 1 is "duration-based", employed when the components of technology versus traditional in blended learning are expressed in units of time. The indicators to employ Method 1 include keywords like "minute", "hour", "day", "week" and "year". Below is the formula for Method 1:

$$Technology : Traditional$$

$$\frac{Class\ time\ for\ intervention}{Total\ Class\ time} : \frac{Class\ time\ for\ traditional}{Total\ Class\ time} \quad (1)$$

Method 2 is "content-based", employed when the components of technology versus traditional in blended learning are expressed in amount of content. The indicators to employ Method 2 include keywords like "portion", "session", "period", "part" and "frequency" (times or number of visitations). Below is the formula for Method 2:

$$Technology : Traditional$$

$$\frac{Amount\ of\ Sessions\ using\ Technology}{Total\ Class\ Sessions} : \frac{Amount\ of\ Sessions\ using\ Traditional}{Total\ Class\ Sessions} \quad (2)$$

Subsequently, the meticulous process of analysis commenced with a comprehensive examination of the 37 selected articles. This meticulous scrutiny aimed to discern and isolate specific keywords that signified either positive or negative feedback, as emanating from the qualifying statements that had been meticulously extracted. This initial phase of analysis involved a systematic and thorough scan of the articles, to identify salient patterns or categories.

3. FINDINGS

Table 1 portrays the ratio of technology versus face to face for 37 included articles the blended learning approaches. The articles are sequenced from the highest percentage of ratio to the lowest percentage of ratio allocated for the technological intervention employed in the respective intervention. Of the 37 samples that had their ratio determined, Method 1 was employed 27 times, while Method 2 was used 10 times. Lo, Han, Wong, and Tang (2021) and Yigzaw, Tebekaw, Kim, Kols, and Ayalew (2019) suggest that the balance between online and in-person instruction in blended learning varies depending on the subject in which it is implemented. The notion of "ratio," is often determined by the course instructor and is based on the needs of the program using blended learning. It may be that a one-size-fits-all approach is not practical for the ratio of blended learning, as different ratios may be needed to address the unique needs, interests, and concerns of different individuals in different context.

Table 1. Ratio of technology vs. face to face (F2F).

No	Article	Ratio (%)		Method of calculation
		Technology	F2F	
1	McCutcheon, O'Halloran, and Lohan (2018)	90	10	M2
2	Tosun (2015)	83	17	M1
3	Cabı (2018)	75	25	M1
4	Ozonur, Yelken, and Tokmak (2018)	56	44	M1
5	Akgunduz and Akinoglu (2016)	50	50	M1
6	Alsancak Sirakaya and Ozdemir (2018)	50	50	M2
7	Bakeer (2018)	50	50	M2
8	Banditvilai (2016)	50	50	M1
9	Bataineh and Mayyas (2017)	50	50	M1
10	Chao, Chen, and Chuang (2015)	50	50	M1
11	Chen and Hwang (2017)	50	50	M1
12	Cosgrove and Olitsky (2015)	50	50	M2
13	Fazal and Bryant (2019)	50	50	M2
14	Hoic-Bozic, Dlab, and Mornar (2015)	50	50	M1
15	Hwang and Lai (2017)	50	50	M1
16	Ige and Tsotetsi (2017)	50	50	M1
17	Inal and Korkmaz (2019)	50	50	M1
18	Jou, Lin, and Wu (2016)	50	50	M1
19	Kara (2018)	50	50	M1
20	Kurt (2017)	50	50	M1
21	Lin, Tseng, and Chiang (2016)	50	50	M2
22	Liu, Chen, Lesgold, Feng, and Wang (2017)	50	50	M1
23	Prescott Jr et al. (2016)	50	50	M2
24	Saritepeci and Cakir (2015)	50	50	M1
25	Schechter, Macaruso, Kazakoff, and Brooke (2015)	50	50	M1
26	Smith and Glass (1977)	50	50	M1
27	Suana, Distrik, Herlina, Maharta, and Putri (2019)	50	50	M1
28	Sulisworo, Agustin, and Sudarmiyati (2016)	50	50	M2
29	Tan and Hew (2016)	50	50	M1
30	Tsai (2015)	50	50	M1
31	Tsai (2015)	50	50	M1
32	Wang and Wu (2018)	50	50	M1
33	Yick, Yip, Au, Lai, and Yu (2018)	50	50	M2
34	Zafonte and Parks-Stamm (2016)	50	50	M2
35	Barhoumi (2015)	33	67	M1
36	Bazelais and Doleck (2018)	25	75	M1
37	Van Niekerk and Webb (2016)	18	82	M1

Table 2 illustrates the 15 articles which reported students' feedback. It is noted that not all 37 articles reported on the students' feedback. Of the 15 articles, the highest deployed ratio at 90%, a study conducted by McCutcheon et al. (2018), yielded positive feedback, *"Participants in the blended group (m = 30.89, sd = 6.54, n = 57) indicated a higher level of satisfaction than participants in the online group (m = 26.49, sd = 6.93, n = 55) and this difference is statistically significant (p = 0.001). The relationship is slightly stronger than that for motivation and attitudes" (p. 36). "Overall, the data supports students' preferences for a blended learning approach to clinical supervision skills." (p. 37).* The lowest ratio of 18%, a study by Van Niekerk and Webb (2016), also received positive feedback, *"78% indicated that they had enjoyed this type of learning. Most, 90%, indicated that they thought that other learners would enjoy this form of instruction." (p. 25). "Many of the open-ended responses that were allowed for additional comments reflected that the students really enjoyed the fact that the e-learning material allowed them to work at their own pace." (p. 26).* Feedback is one of the important facets of blended

learning that cannot be dismissed. The discussions of both the highest and lowest ratio generated positive feedbacks, ergo clearly indicate that regardless the ratio, the integration of technology is essential to support sustainable strategies in teaching and learning approaches (Fleischmann, 2021; Prilop, Weber, & Kleinknecht, 2021). This evidently postulates that blended learning has significant importance and numerous benefits, including increased familiarity with technology, enhanced instruction quality, improved learning outcomes, flexibility, and control (Alshurafat, Al Shbail, Masadeh, Dahmash, & Al-Msiedeen, 2021). Together, they form the bedrock of blended learning's transformative impact on modern education.

Table 2. Students' feedback of the deployed interventions.

No	Article	Feedback	Statement	Ratio (%)	
				Tech.	F2F
1	Banditvilai (2016)	Positive feedback	"The students in the experimental group had **favourable attitudes** towards enhancing their language skills through e-learning." (p. 224) "In addition, there was a **favourable response** relating to motivational aspects delivered through the use of technology." (p. 224) "The data from the questionnaire and the semi-structured interview demonstrates that students **have a positive attitude** towards the use of e-learning because it enables them to become more motivated and more involved in the learning process." (p. 227)	**50**	**50**
		Negative feedback	"Some students interviewed believed that we can use e-learning to aid students' learning, but it **should not be used** to replace the valuable interaction between teachers and students." (p. 227)		
2	Cabı (2018)	Positive feedback	"According to the students, coming to classroom prepared and completing the assignments in the class so that they do not have to do them at home are among the **positive aspects** of this model." (p. 216)	75	25
		Negative feedback	"The students studying outside the classroom stated they **experienced problems** regarding the difficulty of the contents and insufficiency of the resources." (p. 216)		
3	Chao et al. (2015)	Positive feedback	"The EG showed a **positive learning attitude**, for which qualitative and quantitative results can provide strong evidence." (p. 523)	50	50
4	Hoic-Bozic et al. (2015)	Positive feedback	"Students expressed **satisfaction and a positive attitude** towards the effectiveness of the learning model and found the ELARS system useful. They believed that the system **positively influenced their level of engagement** in e-ivities and liked being able to choose between items." (p. 5)	50	50
5	Jou et al. (2016)	Positive feedback	"In general, the SSQ survey results indicated **high degrees of satisfaction** with respect to all of the three scales." (p. 11)	50	50
6	Kurt (2017)	Positive feedback	"PTs in the present study perceived themselves to be **more motivated** in the flipped classroom compared to the traditional lecture-based classroom." (p. 218)	50	50
7	Lin et al. (2016)	Positive feedback	"Many studies have indicated that the blended learning method has **positive impacts** on learning outcomes." (p. 763)	50	50
8	McCutcheon et al. (2018)	Positive feedback	"Participants in the blended group (m = 30.89, sd = 6.54, n = 57) indicated a **higher level of satisfaction** than participants in the online group (m = 26.49, sd = 6.93, n = 55) and this difference is statistically significant (p = .001). The relationship is slightly stronger than that for motivation and attitudes" (p. 36) "Overall, the data **supports students' preferences** for a blended learning approach to clinical supervision skills." (p. 37)	90	10

No	Article	Feedback	Statement	Ratio (%)	
				Tech.	F2F
9	Smith and Suzuki (2015)	Positive feedback	"Within the student satisfaction rating, students enthusiastically indicated **they preferred the online lessons** created from the screen-capture technology. Students selected the option to have their teachers **make more online lessons** for another math chapter." (p. 141)	50	50
10	Suana et al. (2019)	Positive feedback	"Because of the ease of access and practicality of Line, experiment group learners **declared they entered the online class more frequently**." (p. 1018)	50	50
		Negative feedback	"From the answer of questionnaire, it is found that **students faced several challenges**." (p. 1018) "The second **most problem complaining** by the students is the Lines' lack of discussion setting." (p. 1021)		
11	Tan and Hew (2016)	Positive feedback	"Overall, 100% of the students in the experimental group **agreed or strongly agreed** that they found the course motivating." (p. 28)	50	50
12	Tosun (2015)	Positive feedback	"Common comments and explanations indicate that although students **enjoy and appreciate learning and practicing** new vocabulary items through blended learning" (p. 645)	83	17
		Negative feedback	Continuation from the sentence above: "they **did not enjoy** the digital tools as well as in-class activities prepared by the teacher." (p. 645)		
13	Tsai (2015)	Positive feedback	"The data indicates that most students were **satisfied using Blackboard** to assist their learning in writing." (p. 161)	50	50
14	Van Niekerk and Webb (2016)	Positive feedback	"78% indicated that they had **enjoyed** this type of learning. Most, 90%, indicated that they thought that other learners would enjoy this form of instruction." (p. 25) "Many of the open-ended responses that were allowed for additional comments reflected that the **students really enjoyed** the fact that the e-learning material allowed them to work at their own pace." (p. 26)	18	82
15	Wang and Wu (2018)	Positive feedback	"In terms of its **advantages, students pointed out** the novel and interesting activities, convenience of knowledge acquisition, improvement of interest in learning, and more focused, and more relaxed, and so on." (p. 53)	50	50
		Negative feedback	"In terms of shortcomings, students **generally pointed out the disadvantages** of "mobile devices can damage vision", "students who are not self-sufficient can easily become distracted"; some students also noted that the learning methods reduces communication between teachers and students, and students' cooperation." (p. 53)		

4. CONCLUSION

The aim of the study is to systematically aggregate, and quantify the ratio of the interventions used in blended learning studies, as well as a look at the accompanying student feedback. In the course of this investigation, a remarkable revelation emerged—irrespective of the specific technological ratios employed in these blended learning scenarios, a prevailing trend of positive feedback was observed. This intriguing finding challenges the notion that the choice of technological blend holds a decisive influence over students' reactions. Instead, it underscores the potency of well-crafted blended learning methodologies in eliciting favorable responses from learners. This study has significant practical significance in addition to its implications for empirical research. It produces structured guidelines as a result of its thorough analysis, which may help to accelerate the adoption of blended learning. All stakeholders involved in blended learning initiatives—educators, administrators, and curriculum designers—can benefit from these recommendations as a useful resource. Most importantly, this research contributes to the understanding of technology adoption and sustainable development competency.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Conceptualizing and structuring the article, laying the groundwork for our exploration of the topic, M.M.M.; conducted thorough research and gathered essential data, enriching the article with real-world evidence that ensures the accuracy of findings, N.H.C.M.; provided valuable theoretical insights, critically analyzing existing literature and drawing insightful comparisons, M.R.M.; skillfully synthesized a range of perspectives, weaving together diverse ideas into a cohesive narrative that flows smoothly throughout the article, S.F.Z.; addressed potential counterarguments and limitations, adding depth to our discussions and presenting a well-rounded perspective, F.T.; led the development of a thought-provoking conclusion, summarizing key takeaways and highlighting the broader implications of our findings within the larger context of the field, S.F.W. All authors have read and agreed to the published version of the manuscript.

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