



**Mobile Applications Integrated in Blended Learning :
A Systematic Literature Review**

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Article History	Abstract
Received: 1 November 2023 Revised: 15 November 2023 Accepted: 6 December 2023	This systematic literature review explores the use of mobile apps in blended learning, examines the characteristics of the research areas, research objects, and research methods of empirical studies on mobile apps in blended learning, and finally summarizes and organizes the results of the existing empirical studies and suggests implications for future research. This investigation involved a comprehensive search of academic publications within the Web of Science and Scopus databases, focusing on relevant topics. The analysis of the gathered literature indicates that mobile applications serve as efficient, beneficial, and suitable tools for facilitating blended learning. In such learning environments, these applications have the potential to enhance student satisfaction with the course, bolster engagement and motivation, and foster a sense of social connection among learners. However, mobile apps can only be used as an assistive tool for face-to-face learning and cannot replace paper-based assignments or the instructor's guiding role. Future research should attempt to introduce mobile learning apps in blended learning environments and extend the length of experiments to take advantage of mobile apps in order to improve the cognitive depth and breadth of blended learning and engagement.
CC License CC-BY-NC-SA 4.0	Keywords: <i>Blended Learning, Mobile Applications, Design</i>

1. Introduction

As the COVID-19 epidemic subsides and school teaching resumes, online and offline blended learning has become the best choice for Chinese universities. Blended learning is defined as "the thoughtful integration of face-to-face and online learning experiences" [1]. Although blended learning is growing rapidly in China, there are some significant problems with blended learning as observed by researchers. The biggest problem is that current instructors lack guiding principles for blended learning design, while students have also been found to be less engaged in blended learning.

In order to figure out the needs of students, the researcher conducted a survey involving 3000 participants (students in China West Normal University) investigating mobile-assisted blended learning of EFL courses. Based on this study, it was found that mobile devices were the tools students often used in blended learning. In another study, students reported that mobile devices

make it easier for them to do coursework. In addition, they help students communicate better with each other and instructors and improve work quality and knowledge in their field of study [2].

However, they still have many problems using mobile devices to attend blended learning. According to the researcher's survey, 64.9% of the investigated students said mobile-assisted English Learning is distractable, and 41.8% believe they lack guidance when using mobile devices to attend English learning [3]. Rasheed et al. also did a systematic review of the challenges faced by students using blended learning's online component and found that they faced self-regulation challenges and difficulties using technology effectively to study [4].

So, how can mobile applications be utilized to enhance instructional management and instructional design in order to improve teaching effectiveness and student engagement in blended university English learning? This is a question worthy of research.

This review article aims to analyze the current status and findings of existing empirical studies on blended learning that incorporate mobile applications, and thus provide recommendations for teachers' future use of mobile applications in blended learning.

2. Research Methodology

2.1 Research Methodology

The investigation was executed through a methodical literature review. This technique is noted for its explicit and systematic approach to collating literature, employing replicable search methods and strategies to locate and assess relevant publications. Subsequently, these sources are meticulously sifted and filtered based on specific research inquiries or pre-set standards. This process ensures an accurate capture of the current research landscape and the developmental tendencies related to the study's subject matter, aiming to answer the targeted research question [5]. The systematic literature review's strengths are its stringent and transparent nature. It involves defined research queries, extensive searching tactics, precise selection criteria for literature, high-caliber evaluation techniques, thorough data examination, and credible results. Such a method is effective in countering the subjective and biased elements often found in traditional research approaches [6].

2.2 Research Question

In order to understand the current empirical studies on integrating mobile applications in blended learning and teaching, this study identified the following research questions: (1) What are the main characteristics of empirical studies on integrating mobile applications in blended learning (research fields, research objects and research method)? (2) What were the empirical research findings on integrating mobile applications in blended learning?

2.3 Sample Acquisition

1)Literature Search Strategies

To acquire empirical studies of high quality on the integration of mobile apps in blended learning, this research utilized two prominent databases, Web of Science and Scopus. A precise search was conducted focusing on article titles, abstracts, and keywords, using 'mobile app' and 'blended learning' as the primary terms. This search strategy yielded a collection of 191 documents. Among them, the literature search formula of Web of Science database is mobile app (all fields) AND blended Learning (all fields), no publication time limit is set, and a total of 70 articles are retrieved. The literature search formula of Scopus database is (TITLE-ABS-KEY (mobile app) AND TITLE-ABS-KEY (blended AND learning)). No publication time limit was set and a total of 121 articles were retrieved.

2)Literature Screening Criteria

To maintain the precision and trustworthiness of the literature analysis outcomes, and to accurately reflect the current state of empirical research on integrating mobile apps into blended learning, this study established specific inclusion and exclusion criteria for the initially gathered 191 literature pieces, as detailed in Table 1 [7]. Criteria 1 to 6 align with standard systematic literature review methods, ensuring the research sample's accuracy and credibility. Criterion 7 is tailored to select empirical studies with experimental designs, filtering out literature that lacks a defined research question, a rigorous experimental framework, or a clear research methodology. Criterion 8

is aimed at narrowing the focus to literature that specifically addresses the use of mobile apps in teaching and learning within blended learning environments, thereby excluding studies pertaining to other contexts.

Table 1. Literature Selection Criteria

No.	Inclusion Criteria	Exclusion Criteria
1	English Papers	Non-English papers
2	Empirical Studies	Non-Empirical Research
3	Full text available	Full text not available
4	The article is a journal article	Book manuscripts, conference papers, reports, etc.
5	The article contains at least three pages	Posters, short papers or briefs of less than three pages, etc.
6	The article title appears only once	Repeated titles
7	The study includes a clear research question, research methods, and research findings	The study does not present a clear research question, research methodology, or research findings
8	The research context is blended learning	Study context is not blended learning

3)Literature Screening Process

This research adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework for the literature review process. PRISMA, an internationally recognized systematic review methodology, encompasses 27 criteria (such as title, abstract, methods, results, and discussion) across four phases [8]. It mandates a transparent presentation of the literature selection process, including identification, screening, eligibility, and inclusion or exclusion, along with the rationale behind these decisions. This enhances the preciseness of the systematic literature review and meta-analysis report. Following this approach, the study identified 26 relevant papers, comprising 19 from the Scopus database and 7 from the Web of Science (WoS) database. The PRISMA flow diagram illustrating this is depicted in Figure 1. The selected 26 papers were then scrutinized across various dimensions including authorship, publication year, country of origin, journal, research theme, disciplinary background, research methodology, measurement approach, and key findings.

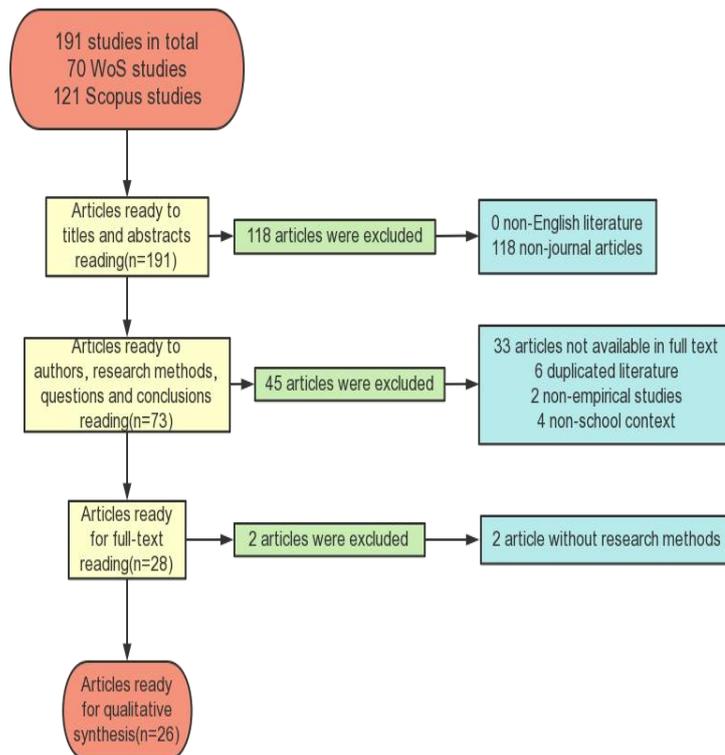


Figure 1. The Flow Diagram of PRISMA

3. Results and Discussion

Empirical research is a unity composed of "real problem - method application - data analysis - conclusion interpretation" [9], which is a necessary way for education to move toward science [10]. This study focuses on the empirical study of mobile applications in blended learning, focusing on the course design, scenarios, and methods of incorporating mobile applications into the empirical study of blended learning. In the following, the basic characteristics of empirical studies on the integration of mobile applications in blended learning will be specifically analyzed according to literature publication, author distribution, research design, research fields, and research methods.

3.1 Literature Publications and Citations

Regarding the publication timeline, empirical studies on the integration of mobile applications into blended learning exhibit a yearly upward trajectory (refer to Figure 2). This trend suggests that this research area is garnering progressively more attention from the academic community. As for the journal distribution, the 26 articles were disseminated across 22 different journals. Among these, a majority, 16 articles (60.7%), appeared in educational journals, followed by 5 articles (14.3%) in psychology journals, and 2 (7.1%) in computer science journals. The remaining 5 articles (17.8%) were published in interdisciplinary journals. The journals with the highest publication counts were BMC Medical Education, Social Work Education, and the Journal of Chemical Education.

In terms of citation frequency, eight of the articles received over 10 citations, and five surpassed the 20-citation mark. Notably, the article referenced as [11], focusing on the utilization of virtual worlds in hybrid education, leads with 49 citations. This is closely followed by the study [12], which examines the role of mobile augmented reality in self-directed, blended learning in the medical field, cited 44 times. It's evident that the articles with higher citation counts predominantly explore themes around mobile applications employing virtual reality and similar technologies. This trend underscores the growing interest in research on the integration of mobile applications with VR and related technologies in blended learning. It should be noted that the article by Diaz et al. [11] was published in 2020, meaning that it received the most citations in a relatively short period of time.

3.2 Author Distribution Characteristics

In order to show the distribution of authors of empirical studies on mobile apps integration in blended learning, the study analyzed 26 sample papers with the first author as the unit of analysis and found that the authors were from a total of 14 countries, and their regional distributions were Europe (n = 16, 61.5%), North America (n = 4, 15.4%), Oceania (n = 4, 15.4%), and Asia (n = 2, 7.7%). In terms of the number of published authors, there are 9 UK authors, accounting for 34.6% of the total number of authors, indicating that UK scholars are the main group of empirical research on mobile application integration in blended learning.

3.3 Study Design Features

To delve deeper into the research contexts and experimental frameworks used in studies involving mobile apps in blended learning, this research conducted a systematic examination of the selected literature, focusing on aspects such as disciplinary background, research subjects, and sample sizes. The exploration into disciplinary backgrounds revealed that over the past decade, research on mobile apps within blended learning has extended beyond the educational domain. Significant attention is also evident from fields such as medicine, psychology, and STEM, with a particular focus on learning inputs. Notably, the disciplines of education and medicine are at the forefront in terms of interest and have a wealth of research cases (as illustrated in Figure 2).

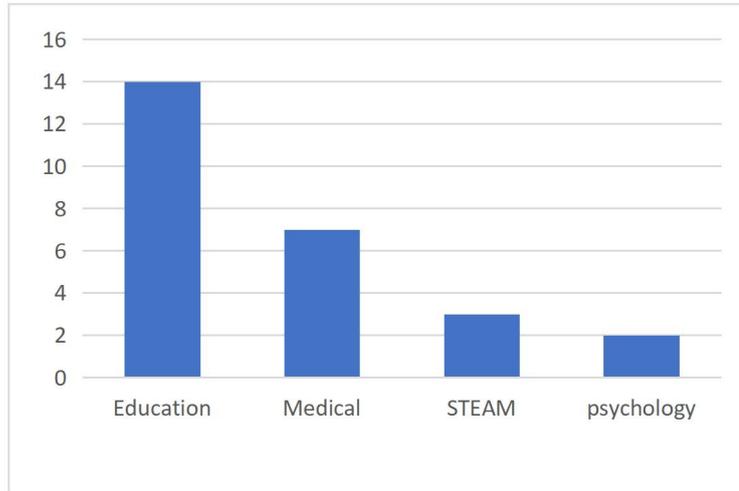


Figure 2. Study Field(n=26)

In terms of the categories of research subjects, 69.2% (n = 18) of the empirical studies of mobile apps in blended learning were conducted with college students, 11.5% (n = 3) with postgraduates, 7.7% (n = 2) with middle school students, 7.7% (n = 2) with teachers, and 3.8% (n = 1) with other adults (Figure 3). It can be seen that the subjects of empirical research on mobile apps in blended learning are mainly college students, with relatively little attention paid to teachers and secondary school students. This may be due to the fact that when conducting experimental studies for primary and secondary school students, it is necessary to obtain the consent of the guardian, which makes it more difficult to conduct empirical studies.

Regarding the sample sizes used in empirical studies on mobile apps in blended learning, the distribution is as follows: 30.8% (8 studies) had fewer than 40 participants, 23.1% (6 studies) included 41-80 participants, and 15.4% (4 studies) involved more than 200 participants. The remaining studies displayed a relatively balanced distribution in terms of sample size (as shown in Figure 4). This pattern indicates that the majority of these studies tend to manage sample sizes around the size of a typical class. This approach aids in streamlining research design and managing variables effectively, while also circumventing the limitations that come with too small a sample size. On the other hand, studies with sample sizes exceeding 200 are generally longitudinal studies, tracking a larger group of participants over time.

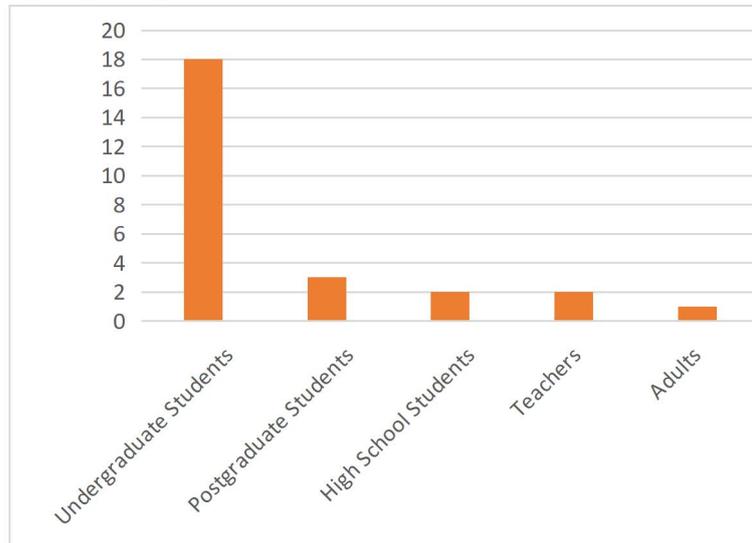


Figure 3. Research Subjects

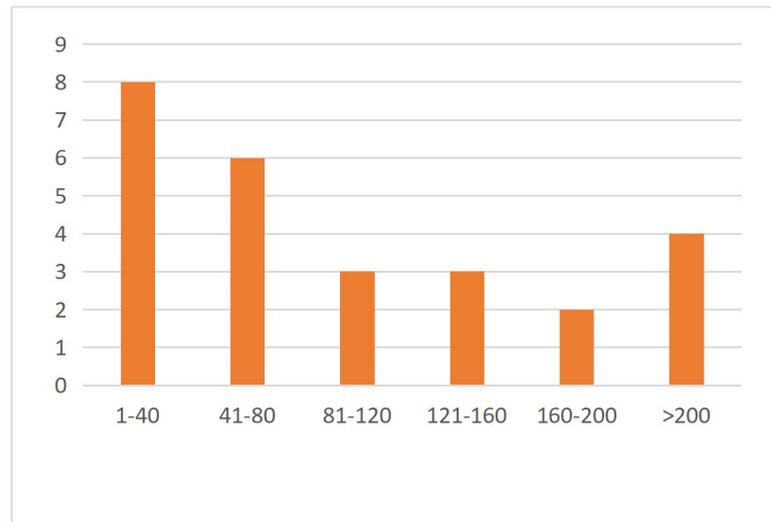


Figure 4. Sample Size

3.4 Characterization of Research Methods

To effectively leverage the empirical research frameworks used in studies of mobile apps within blended learning environments, this study categorizes the research methodologies into three distinct types: experimental design, quasi-experimental design, and non-experimental design. Experimental design refers to the research that controls the experimental conditions and arranges the experimental procedures with the purpose of analyzing the relationship between the experimental conditions and the experimental results, and generally adopts randomized grouping; quasi-experimental design refers to the research that neither directly manipulates the independent variables nor strictly controls the additional variables in the study, and does not use randomized grouping but carries out multi-group categorization and measurements, for example, setting up a control group and a control group, and so on. The others are non-experimental designs. An analysis of the research paradigms and data analysis methods of the 26 empirical research articles in the literature (Figure 5) revealed that 10 articles used experimental designs (27.1%), 11 articles used quasi-experimental designs (35.4%), and 5 articles belonged to non-experimental designs (37.5%). In terms of data analysis methods, the experimental design was mostly quantitative ($n = 5$, 19.2%), the quasi-experimental design was also dominated by quantitative studies ($n = 6$, 23.1%), and the non-experimental design was both qualitative and quantitative studies comparing average data ($n = 2$, 7.7%). Overall, the majority of studies were predominantly quantitative ($n = 13$, 50%) and mixed methods ($n = 8$, 30.8%), with fewer using purely qualitative studies ($n = 5$, 19.2%).

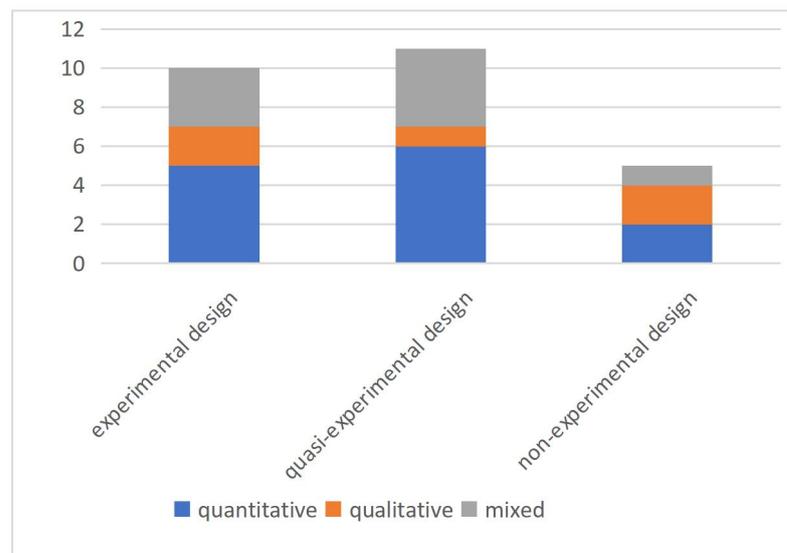


Figure 5. Research Methodology

3.5 Analysis of Empirical Findings

The researcher analyzed and organized the findings of 26 empirical studies on the integration of mobile apps in blended learning and found that they can be divided into four major directions: students' affective attitudes toward mobile apps; teachers' approaches to classroom design for mobile apps in blended learning; the impact of mobile app integration on students' academic performance or other affective variables, and the criteria and concerns for mobile app selection.

The Effect of Mobile Apps' Incorporation on Student Academic Performance or Other Affective Variables.

Of the 26 empirical studies on the integration of mobile apps in blended learning environments screened by the researcher, more than 70% (n=19) of the articles investigated the impact of using mobile apps in blended learning on students' academic performance or other affective variables.

The following scholars mentioned that the participation of mobile apps led to an improvement in students' academic performance or course performance: Mobile platform software solutions are showing promising results in enhancing learning outcomes, particularly in fields like engineering vocabulary acquisition [13]. The study by Noll involving augmented reality groups [12] indicated potential improvements in long-term knowledge retention. Lameris's research highlights the efficacy of a smartphone-based formative testing application in boosting study habits and performance among (bio)medical students [14]. Zamborova & Klimova observed a favorable response to using a reading app in business English courses [15]. Furthermore, a mobile learning application for vocabulary was found to be beneficial in blended English language learning contexts [16]. This study demonstrated that students engaged in blended learning with mobile apps achieved superior outcomes compared to those in traditional, classroom-based settings. Additionally, it was noted that students' satisfaction with the application increased over time.

Nevertheless, the research by Coer et al. revealed that the scenario-based design principles used in mobile platform learning had mixed effects on student outcomes, with both positive and negative impacts observed [17]. Similarly, Thijssen et al.'s study indicated that providing detailed feedback in a web-based formative testing application did not significantly boost study behavior or performance among (bio)medical students, potentially due to a ceiling effect [18].

Researchers have been examining the effects of mobile apps on aspects like student learning satisfaction, engagement, and motivation within blended learning environments. Studies involving a blend of traditional lectures and mobile learning, such as the use of the iPOT app in health science undergraduate programs, have shown notable enhancements in student motivation, mood, and satisfaction compared to conventional teaching methods [19]. Nadeem et al. highlighted that such instructional approaches not only engage students but also boost their eagerness to learn [20]. Bock et al. reported high levels of satisfaction among students using an app as a supplementary resource in their courses [21]. Additionally, a study focusing on digitally supported reasoning interventions found positive impacts on reducing paranoia [2]. Ali's research underscored the effectiveness of Viber messenger in fostering student collaboration and maintaining social presence within a blended learning community, particularly in geographically dispersed settings [22]. Furthermore, the implementation of Open Educational Resources (OER) has been shown to heighten student motivation, especially in terms of attention, relevance, and confidence [23].

3.6 Teachers' Approaches to Class Design for Mobile Apps in BL

Of the 26 empirical studies on the introduction of mobile apps in blended learning environments screened by the researcher, more than 38% (n=10) of the articles investigated course design and recommendations for teachers to use mobile apps in blended learning.

Rahman et al.'s study first suggested that educational videos as OER should be confined to 2 min [24]. And these videos should be compatible with mobile devices and optimized for sharing on social media. Alkhunaizan reported that assignments and homework need to be sent and received by instructors [25]. Furthermore, learners' performance can also be evaluated with m-Learning. However, Ikonnikova et al. believed that the assessment of such learning means should also make allowance for the possibility of completing tasks outside the digital space, because almost all students and teachers (98%) found that writing paper by hand was a good way to store learning traditions [26].

Most scholars treat mobile apps as a useful supplement to classical education formats within the context of a blended learning approach [20], [21], [27], [28]. Students regard the app as a complement, rather than a replacement of the teacher or face-to-face teaching [21], [27], [28].

Several experts have addressed the complexities and considerations involved in creating mobile apps for blended learning. Key challenges identified when integrating technology into education include issues related to infrastructure, educators' technological proficiency, and educational policies [29]. Zamborova & Klimova discussed various pedagogical implications of incorporating contemporary mobile reading apps into English language teaching within blended learning frameworks [15]. Polakova & Klimova also confirmed the effectiveness of mobile applications for vocabulary learning in blended English language education [16]. Other researchers advocate for the potential of mobile apps as platforms for interactive activities. For instance, a no-cost, quiz-based mobile game has been developed to engage students in testing their knowledge and improving their understanding of organic structures and reactivity in an entertaining and interactive manner [30].

3.7 Mobile App Selection Criteria and Concerns

Among the 26 empirical studies screened by the researcher on the introduction of mobile apps in blended learning environments, 12% (n=3) of the articles presented criteria and concerns about the use of mobile apps in blended learning.

In their research, Belarbi et al. developed a comprehensive set of criteria aimed at encompassing the key technical considerations for designing mobile Small Private Online Courses (SPOCs). These guidelines are intended to assist educators in the creation of SPOCs specifically tailored for delivery via mobile applications [31].

Turner et al. also gave a guideline for all those interested in developing digital mobile resources. The most important among those is to reflect the collaboration between leading academics, stakeholders and developers [32].

Finally, Lin advocates the importance of integrating digital topics and skills into academic and professional development programs, emphasizing that this is essential to equip the field for the increasingly digital nature of healthcare environments [33].

Students Attitudes Toward Mobile Apps in BL (Blended Learning).

In the 26 empirical studies on the introduction of mobile apps in blended learning environments screened by the researcher, only more than 7% (n=2) of the articles focused on investigating students' affective attitudes towards mobile apps in blended learning.

Alkhunaizan's research revealed that learners demonstrated favorable responses to the incorporation of mobile learning applications [25].

A study conducted by Ali revealed that students preferred technology tools that helped them to communicate and receive learning support more easily and quickly. The use of Viber Messenger has been shown to improve collaboration among students and sustain social interaction within a blended learning community spread across various locations [22].

4. Conclusion and Recommendations for Future Research

The results of this review indicate that most students have a natural affinity for mobile apps and consider them to be effective, useful and appropriate learning tools for blended learning [12], [13], [14], [16]. Empirical studies have demonstrated that it enhances students' course satisfaction, engagement, motivation and social presence in blended learning [2], [19], [20], [21], [22]. However, mobile apps can only be used as an assistive tool for face-to-face learning and cannot replace paper-based assignments or the instructor's guiding role [21], [27], [28], [20]. Unfortunately, a small number of scholars have also stated that the participation of mobile apps in blended learning has no effect on students' various learning variables [17], [18]. Future research should attempt to introduce mobile learning apps in blended learning environments and lengthen the length of experiments to take advantage of mobile apps in order to improve the depth and breadth of cognition and engagement in blended learning.

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