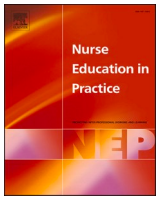
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Systematic literature review on the effects of blended learning in nursing education

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ABSTRACT

Aim: The study aimed to comprehensively analyze and evaluate the effects of blended learning in nursing education.
Background: Blended learning addresses significant challenges in nursing education by offering flexible and adaptive learning environments that support the development of both theoretical knowledge and practical skills. Its importance grew post-COVID-19. Although some reviews have synthesized its effects in nursing education, they often focused on a limited scope and studies, leaving gaps in understanding its broader impact.
Design: Systematic literature review.
Methods: We employed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to search for literature published in PubMed, CINAHL, Web of Science, EMBASE, ERIC, Scopus and Cochrane Library from 2000 to June 26, 2024. Two researchers independently screened each article for eligibility and extracted the data.
Results: This review included 54 studies and found that blended learning positively influenced nursing students in five key areas: academic performance and skill development, learning engagement and motivation, self-management in learning, psychological and emotional well-being, learning experience and satisfaction. These were captured in a visual model showing the comprehensive impact of blended learning. Critical research gaps were identified, including a lack of randomized controlled trials and limited studies on mental health and clinical thinking abilities.
Conclusions: The results of the study showed that the effects of blended learning in nursing education were positive and multi-dimensional. Despite some inconsistencies in findings, blended learning was shown to offer significant advantages over traditional learning, though further research is required to address areas of uncertainty.

1. Introduction

Blended learning (BL) is a learning strategy that effectively integrates Information and Communication Technology (ICT) with traditional education approaches. It combines online and face-to-face learning (Bruggeman et al., 2021; Hrastinski, 2019). This approach is widely recognized for its adaptability and effectiveness in bridging theoretical knowledge with practical application, which is crucial for nursing education (Hsu, 2011; Janes et al., 2023). The rapid advancements in globalization and ICT have transformed educational needs, especially in disciplines like nursing that require theoretical knowledge and clinical practical skills. In addition, with the increasingly complex development needs of healthcare industry, the requirements for future nurses are getting higher and higher, traditional education model can no longer meet the requirements of cultivating future health guards (De Gagne et al., 2018; Jiang, 2004). The COVID-19 pandemic has accelerated the shift to BL, underscoring its necessity to meet nursing students' urgent and varied learning needs (Jowsey et al., 2020).

BL combines the advantages of traditional learning and online learning and makes up for the disadvantages of pure online learning and traditional learning (Niu et al., 2023). Compared with traditional and online learning, it provides learning flexibility, allowing students to

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manage their learning schedules while enhancing engagement and promoting self-regulated learning (Li et al., 2022; Shim and Lee, 2020). Moreover, integrating synchronous and asynchronous learning activities facilitates a more interactive educational environment that helps to fit the gap between theory and practice, which is crucial in nursing education where practical skills are essential (Hege et al., 2020). Given these dynamics, BL is not just a beneficial educational model but also a necessary evolution in nursing education to prepare students effectively for future challenges in healthcare. This model ensures that nursing education remains responsive to the demands of a rapidly changing healthcare industry, making it an indispensable part of nursing education strategies.

Extensive research supports the positive effects of BL on nursing students' academic performance and clinical thinking ability. Studies have demonstrated improvements in students' knowledge (Ding et al., 2023; Jiang et al., 2023; Lv et al., 2024), skills (Imani-Goghary et al., 2023; Okuroglu and Alpar, 2022) and engagement (Arien-Zakay, 2024). Further benefits include enhanced clinical thinking abilities like critical thinking (Cao et al., 2021; Park and Yi, 2023), clinical reasoning ability (Arisudhana and Martini, 2022; Gouifrane et al., 2020) and clinical judgment ability (Oh, 2019). Additionally, BL fosters self-directed learning and independent learning (Duan et al., 2024; Lv et al., 2024), boosts self-efficacy (Chung et al., 2022) and increases learning satisfaction (Shorey et al., 2018; Wang et al., 2023). Apart from these, it was also found to be associated with some mental health such as depression (Losa-Iglesias et al., 2023) and academic stress (Gerdprasert et al., 2011).

Although the benefits and drawbacks of BL in nursing education were widely investigated in the existing literature, studies differ widely in their outcome variables, research designs (e.g., Randomized Controlled Trials, Quasi-Experimental) and theoretical framework (e.g., constructivist theory, Community of Inquiry framework). They are also conducted in varied contexts, such as countries (e.g., China, Singapore, Malaysia). Also, the duration of interventions in RCTs or quasi-experimental designs ranges from a few hours to several semesters. Accordingly, instead of leaving a body of scattered literature on the benefits and drawbacks of BL, scholars have argued for consolidating this fragmented knowledge. This consolidation would provide researchers with an overview of the outcome variables studied and the methodologies used (e.g., research design, theoretical framework) (Du et al., 2022; Niu et al., 2023). Such a comprehensive resource would help identify research gaps and guide future investigations into the effects of BL in nursing education.

In this regard, some researchers have conducted a literature review on the effects of BL in nursing education (Du et al., 2022; Kanika and Kaur 2020; Li et al., 2019; McCutcheon et al., 2015; Mulyadi et al., 2020; Niu et al., 2023; Peng et al., 2022) (refer to Table 1 for more details). While these reviews have enriched the extant body of knowledge, most have covered a very limited number of studies. To illustrate, Niu et al. (2023) have covered only 26 studies, whereas Li et al. (2019) only 8 studies. This limitation can primarily be attributed to the narrow scope of these reviews. Many reviews restrict their scope to specific aspects of the BL effect, such as Niu et al. (2023), who concentrated solely on knowledge, skills, critical thinking ability and mental health and Li et al. (2019), who focused on knowledge, skills and satisfaction. By concentrating on a narrow set of outcome variables, these reviews may overlook a broad spectrum of valuable research that could offer deeper insights into the diverse effects of BL. This selective approach can result in a fragmented understanding of the subject, highlighting the need for more comprehensive reviews encompassing a wider range of studies and perspectives. Additionally, the existing reviews have covered studies only up to 2023. However, the literature related to the effects of BL may have grown rapidly since then. As a result, many newer studies exploring BL's impact in nursing education may not be included in their reviews. This could lead to a gap in the current understanding, so we underscore the importance of updating reviews to include recent research.

Table 1
Systematic literature review on blended learning in nursing education.

No.	Authors	Topic variables	Quantity	Search period
1	Niu et al. (2023)	knowledge, skills, critical thinking ability, mental health, blended learning design, nursing student attitudes toward blended learning	26	2010–2023
2	Du et al. (2022)	knowledge, skills, satisfaction	25	2007–2021
3	Mulyadi et al. (2020)	skills, knowledge, attitudes, self-efficacy, problem-solving abilities, willingness to perform resuscitation	6	2010–2020
4	Kanika and Kaur (2020)	knowledge, skills clinical-decision-making and attitude	21	2008–2019
5	Li et al.(2019)	knowledge, skills, and satisfaction	8	2007–2018
6	McCutcheon et al. (2015)	performance, clinical skill, knowledge, self-efficacy, clinical confidence and user experience, satisfaction	19	1995–2013
7	Peng et al. (2022)	learning experience	9	—2021

Addressing the previously discussed research gaps, this study systematically and comprehensively reviews studies on the effects of BL in nursing education up to 2024. The goal is to provide an updated, aggregated, and comprehensive view of the impact of BL on nursing students. This study also examines how existing studies are conducted, including aspects such as research design, sampling, and intervention design, which help identify research gaps and inform potential avenues for future research.

2. Methodology

This systematic review followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which is an internationally accepted method for Systematic Reviews and Meta-Analyses to formulate research strategies such as literature retrieval, inclusion and exclusion criteria and data extraction (Page et al., 2021). The PRISMA flow diagram of the screening and selection procedure for the study was shown in Fig. 1.

2.1. Search strategy

To accurately and comprehensively search for the literature related to the effects of BL in nursing education, learned from the existing relevant studies (Du et al., 2022; Kanika and Kaur, 2020; Niu et al., 2023), we developed a rigorous and systematic search strategy. We searched PubMed, CINAHL, Web of Science (WoS), EMBASE, ERIC, Scopus, and the Cochrane Library for publications in English up to June 2024. The above 7 databases contain the main nursing and education databases, which can ensure the comprehensiveness of the search results and the quality of the search articles.

The terms "blended learning", "hybrid teaching model", "mix learning" are often used interchangeably in the existing literature (Harasim, 2000; Lockey et al., 2022; Wang and Liao, 2020). Meanwhile, to avoid incomplete literature retrieval, the researchers searched for synonyms of blended learning from sources such as encyclopaedias, dictionaries, thesauruses and prior studies (Hu and Raman, 2024). The final search terms included: blended learning, blended teaching, BL, blended instruction, hybrid learning, hybrid teaching, mixed learning, mixed teaching, nurs* , nursing education, nursing learning, nursing student. The term "flipped learning" OR "flipped classroom" OR "flipped

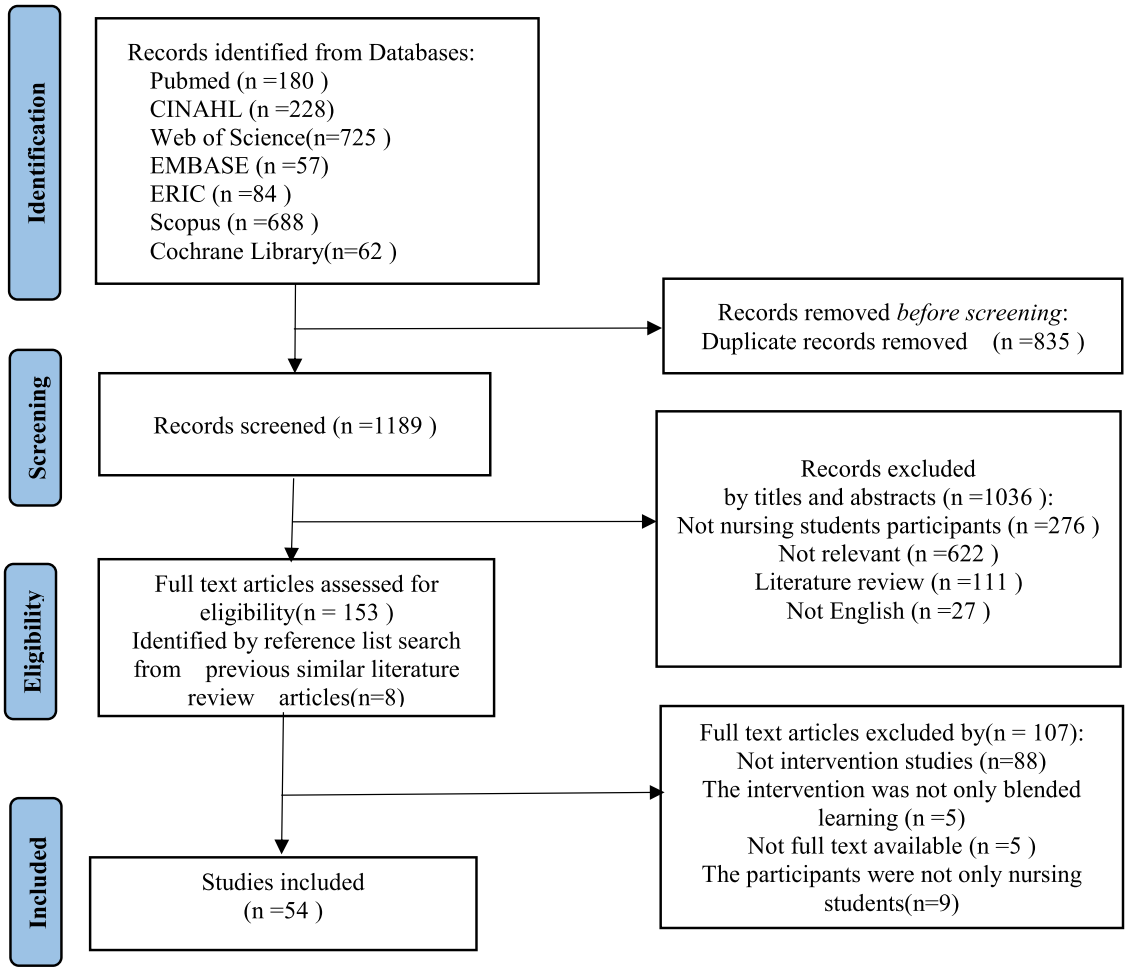


Fig. 1. PRISMA flow diagram of the screening and selection procedure for systematic reviews.

class" OR "flipped teaching" OR "inverted classroom" OR "inverted class" OR "inverted teaching" OR "inverted learning" were excluded because the pre-class element does not always include an online learning element (Lockey et al., 2022). The detailed search strategy is shown in Supplementary Table S1.

In addition, we manually searched the references of the included studies to identify any eligible original research. As the concept of blended learning was not formally described until the early 2000s, the initial date for the search was set as January 1, 2000 (Lockey et al., 2022).

2.2. Inclusion and exclusion criteria

Researchers recommended that systematic reviews of health care intervention studies should be conducted based on PICOs (participants, interventions, comparison, outcomes and study design) principle (Liberati et al., 2009). Therefore, to ensure the comprehensiveness of the literature analysis, PICOs framework was followed to make the eligibility criteria for inclusion and exclusion.

The inclusion criteria: 1) the participants were only nursing students; 2) the intervention group implemented blended learning (combining online learning and face-to-face learning); 3) the control group implemented traditional face-to-face learning or online learning; 4) published between 2000 and June 2024; 5) peerreviewed only.

The exclusion criteria: 1) intervention strategy included not only BL but also other types of intervention; 2) without original data or essential data was missed and could not be obtained by contacting the authors; 3) with only abstracts and full text is not accessible.

2.3. Data extraction

We used Endnote software to remove the duplicates. The two authors (WR and RA) independently screened and reviewed the titles and abstracts, then obtained the full text of all potentially eligible articles for further screening. The extracted information included author, publication year, publication journal country/region, research design, sample type, intervention group (N), control group (N), duration of intervention, and results. Any disagreements or discrepancies were discussed among the two authors until a consensus was reached. If some data were missing or incomplete, we contacted the original author to obtain the relevant data.

3. Results

3.1. Preliminary literature search results

In total, 2024 potential articles were initially retrieved from the 7 databases from January 1, 2000, to June 26, 2024. 1189 articles were left after duplicates were removed using EndNote software. Among the remaining articles, 1036 articles were excluded after the title and abstract screening because the topics were not relevant (n = 622), the participants were not nursing students (n = 276), not original articles but literature review (n = 111) and not published in English (n = 27). In addition, in the supplementary literature search, only 8 articles were identified from reference list of previous similar literature review. After full text articles assessed for eligibility, 107 articles were excluded because the full text articles were not accessible, not studying BL or the

participants included not only nursing students but also those from other field of study. To illustrate, while Arien-Zakay (2024) conducted a study on BL, particularly the integration of online and offline learning, the author actually focused on a combined approach using flipped classroom and problem-based learning methods. It is important to recognize that these methods may not inherently involve any online content, which distinguishes them from the broader concept of BL. Therefore, the study was excluded. Finally, 54 studies were included in this systematic review. The characteristics of included studies were shown in Supplementary Table S2.

The included studies started in 2007 and showed an upward trend from 2018, especially in 2023, as shown in Fig. 2. The authors came from 20 countries and the top three countries were China, Republic of Korea, United States of America, details are shown in Fig. 3.

3.2. The effects of BL in nursing education

Through thematic analysis of the included studies, we have synthesized the effects of BL in nursing education, which can be categorized into five main areas: academic performance and skill development, learning engagement and motivation, self-management in learning, psychological and emotional well-being and learning experience and satisfaction.

3.2.1. Effects of BL on nursing students' academic performance and skill development

In the field of nursing education, BL has a positive impact on students' academic performance and skill development (Du et al., 2022; Niu et al., 2023), providing a comprehensive platform for the acquisition of knowledge and skills.

The effects of BL on nursing students' knowledge acquisition are widely studied. Numerous studies have shown that BL can significantly enhance students' theoretical knowledge levels (Duan et al., 2024; Jiang et al., 2023). By integrating online and offline resources, BL allows students to access to diverse materials and supports self-directed learning. Its flexibility lets students learn at their own pace, helping to consolidate and deepen their understanding of course content. For example, Niu et al. (2023) highlighted that BL is more effective than traditional teaching, as students can engage with learning materials in multiple ways, thereby improving the comprehensiveness and depth of their knowledge acquisition. However, other studies have reported no significant differences in academic performance between BL and non-BL groups (Alshawish et al., 2021; Berga et al., 2021; Huang et al., 2021; Liu et al., 2021, 2020; Perez et al., 2022; Yu et al., 2021).

Nursing is a highly practical discipline, and developing practical skills is an important goal of nursing education. BL enhances these skills by providing more opportunities for practice and feedback through tools (e.g., online simulations, virtual labs and case studies), allowing students to practice and apply skills in a safe and controlled environment. For instance, studies have shown that BL effectively improves nursing students' clinical skills (Imani-Goghary et al., 2023). Students can preview procedural steps through online videos and other resources before hands-on practice, leading to better performance during practical operations (Y. Li et al., 2023; Y. R. Li et al., 2023; Okuroglu and Alpar, 2022). Furthermore, BL enhances nursing students' critical thinking (Cao et al., 2021; Jang and Hong, 2016; Park and Yi, 2023; Yu et al., 2021), clinical reasoning (Arisudhana and Martini, 2022; Gouifrane et al., 2020) and clinical judgment skills (Oh, 2019) through virtual cases and interactive case analysis on online platforms.

3.2.2. Effects of BL on nursing students' learning engagement and motivation

In nursing education, learning engagement refers to the level of students' participation in learning activities, including cognitive engagement, emotional engagement and behavioral engagement (Bayoumy and Alsayed, 2021; Heo et al., 2022). BL has been found to be effective in enhancing learning engagement and motivation. By combining asynchronous online activities with synchronous face-to-face learning, BL provides a more diverse and interactive learning environment, fostering deep engagement and significantly improving students' learning engagement (Arien-Zakay, 2024; Morton et al., 2016). Additionally, the flexibility of BL allows students to better manage their study time, with research showing that students in BL groups spend significantly more time studying than those in non-BL groups (Jiang et al., 2023). However, some studies have shown that BL has no effect on academic engagement (Saad et al., 2021).

Learning motivation is the intrinsic driving force for students to engage in learning activities. BL significantly improves students' learning motivation by providing autonomous learning environment and personalized learning path (Choi and Kim, 2018; McCutcheon et al., 2018). In addition, interactive elements in BL, such as online discussions and collaborative projects, provide students with social support and positive feedback, further motivating students and making them more actively engaged in the learning process.

BL also had a positive impact on self-efficacy, which refers to students' beliefs about their capabilities to complete learning task and achieve their goal (Moon and Hyun, 2019). Through timely feedback and personalized support, BL significantly enhances students'

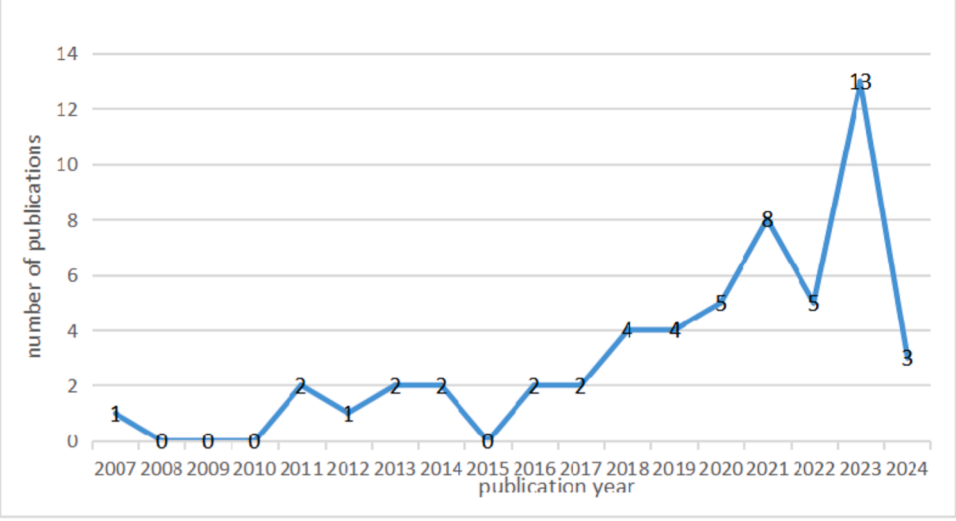


Fig. 2. Distribution of studies by publication year.

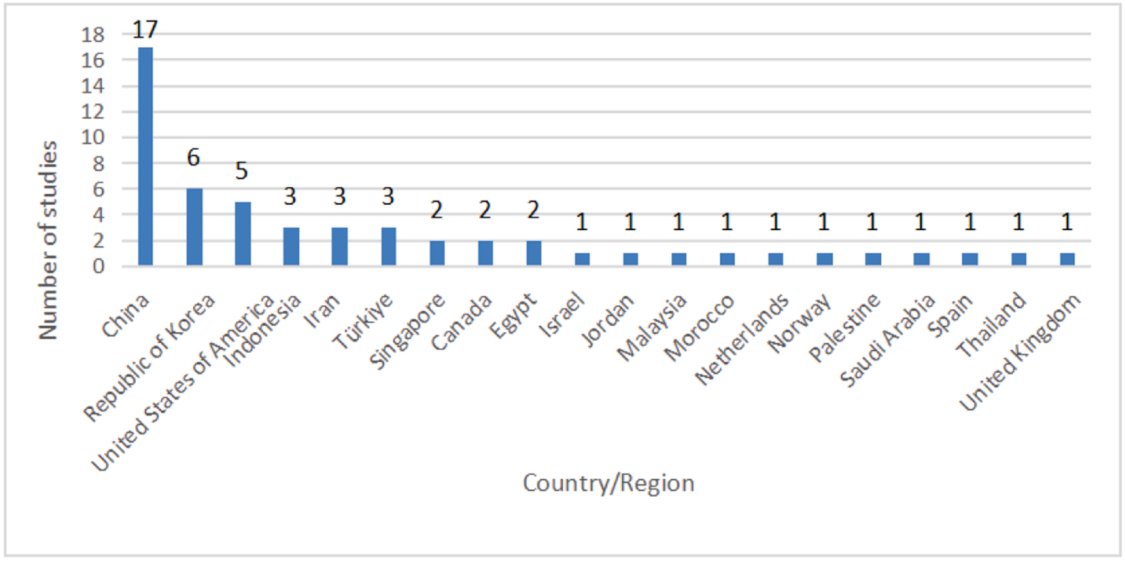


Fig. 3. Distribution of studies per country. Note: United Kingdom, United Kingdom of Great Britain and Northern Ireland.

self-efficacy (Lv et al., 2024; Plemmons et al., 2018; Shorey et al., 2018; Q. L. Wang et al., 2023). In a BL environment, the combination of online resources and face-to-face interactions provides continuous and immediate feedback, enabling students to quickly correct errors and consolidate their understanding. This immediate reinforcement builds confidence in their ability to master the material. Furthermore, through adaptive learning technology and personalized teacher guidance, BL provides personalized support that meets students' specific needs and helps them overcome challenges more effectively. As a result, students feel more competent and confident in their abilities, leading to increased motivation and deeper engagement in learning activities (Lv et al., 2024; Q. L. Wang et al., 2023). However, some studies have shown that BL has no effect on self-efficacy (Berga et al., 2021; Moon and Hyun, 2019).

3.2.3. *Effects of BL on nursing students' self-management in learning*

Self-management in learning focuses on students' ability to independently organize, monitor and regulate their learning process. It encompasses skills like time management, goal setting and self-assessment, and self-directed learning (Duan et al., 2024; Non and Kim, 2019). BL enhances nursing students' self-management, such as self-directed and independent learning abilities by providing flexible online modules and personalized resources. Self-directed learning ability refers to capacity to plan, monitor and evaluate their learning process. Previous studies have demonstrated that BL can significantly improve the self-directed learning ability of nursing students by providing them with online learning modules, self-assessment tools and personalized learning plans (Duan et al., 2024; Y. Li et al., 2023; Non and Kim, 2019; Zhang et al., 2022), The above researches showed that the online learning module in BL encourages students to explore knowledge independently. It also enables them to adjust their learning strategies and choose appropriate learning resources according to their own learning progress.

Independent learning refers to the student's ability to learn effectively without direct guidance from a teacher. BL significantly enhances the independent learning ability of nursing students by providing rich learning resources and offering flexible learning schedules (Lv et al., 2024). In a BL environment, students can freely access and choose a wealth of learning materials that best suit their needs and manage their study time independently. These may make students more confident and capable when facing or tackling complex learning tasks, thus improving their independent learning ability. However, research by Gagnon et al. (2013) found that BL did not directly impact nursing students' self-directed learning readiness.

3.2.4. *Effects of BL on nursing students' psychological and emotional well-being*

Mental health plays a key role in student development. However, there are very limited studies on the effect of BL on the mental health of nursing students. For example, Losa-Iglesias et al. (2023) found that BL could reduce the depression level of nursing students and Gerdprasert et al. (2011) found that BL could relieve the stress of nursing students. The online interaction and timely and continuous feedback in the BL environment provide students with more emotional support and social opportunities, which helps relieve students' depression and stress. On the other hand, however, some mental health-related indicators, such as resilience, self-esteem, anxiety and academic stress, were found by Losa-Iglesias et al. (2023) to have no statistically significant differences between the BL group and the non-BL group.

3.2.5. *Effects of BL on nursing students' learning experience and satisfaction*

The implementation of BL has a notable impact on nursing students' learning experiences and satisfaction. In terms of learning experience, there are positive aspects, such as students could learn at their own pace, used online resources for review and reinforcement and participate in interactive discussions and practical activities. This flexibility and diversity create positive learning experience (Hsu, 2012; Shorey et al., 2018). However, there are also negative experiences, such as being worried that online learning might become a burden and being easily distracted while watching videos (Y. R. Li et al., 2023). Additionally, BL offers greater flexibility but places higher demands on student autonomy, which can reduce learning efficiency for some students (Y. R. Li et al., 2023). Some students struggle to adapt to the BL environment due to passive learning habits (L. Wang et al., 2023). Regarding learning satisfaction, research indicated that BL significantly improves nursing students' satisfaction (Duan et al., 2024; Perez et al., 2022). However, studies by (Blissitt, 2016; Gagnon et al., 2013; Huang et al., 2021; Jang and Hong, 2016) found that BL had no effect on nursing students' learning satisfaction.

In summary, by integrating numerous research findings, it is evident that BL, as a teaching model combining traditional face-to-face and online learning, has multifaceted impact in nursing education. Its effects are reflected not only in academic performance and skill development, but also in areas such as learning engagement and motivation, self-management in learning, psychological and emotional health and learning experience and satisfaction. Based on this, we have developed a model illustrating the effects of BL in nursing education, which provides

a comprehensive overview of BL's effects in nursing education, as detailed in Fig. 4.

3.3. The research design and methods in the included articles

We analyzed the research methodology used in the included articles, including study design and sampling and intervention design.

3.3.1. Study design and sampling

Among the 54 included studies, 40 were quasi-experimental studies and 14 were randomized controlled trials (RCTs). The participants were primarily undergraduate nursing students from different grades (Okuroglu and Alpar, 2022; Park and Yi, 2023). Regrettably, many studies did not specify their sampling methods (Ding et al., 2023; Duan et al., 2024; Govindan et al., 2023; Imani-Goghary et al., 2023; Kestel and Korkmaz, 2023). In studies where sampling methods had been specified, the most frequently reported sampling method is convenience sampling (Berga et al., 2021; Blissitt, 2016; Montaseri et al., 2023). Convenience sampling is notable for its ease of use and relatively low cost associated with its application, with the main consideration of potential participants being whether it is easy to be located or recruited (Sarstedt et al., 2018). Therefore, convenient sampling studies mainly targets potential participants who are easily available and accessible. Only 10 of these studies employed random sampling methods (Arisudhana and Martini, 2022; Cao et al., 2021; Gagnon et al., 2013; Jiang et al., 2023; Y. Li et al., 2023; Moon and Hyun, 2019; Moradimokhles and Hwang, 2022; Park and Yi, 2023; Yu et al., 2021; Zhang et al., 2022).This sampling method ensures that all individuals in the study population have an equal opportunity of being selected, resulting in a more representative sample (Sarstedt et al., 2018). The sample sizes across different studies varied significantly, ranging from 16 to 849.

3.3.2. Intervention design

Intervention studies primarily compared the effects of BL with traditional non-BL approaches in nursing education. The BL group primarily used information technology to conduct online learning through platforms such as websites, Rain Classroom and Massive Open Online Courses (MOOCs), combined with traditional classroom instruction facilitated by various teaching modes, such as the Rain Classroom and Presentation-Assimilation-Discussion (PAD) class (Lv et al., 2024) and the O-AMAS (Objective, Activation, Multi-learning, Assessment, Summary) model (Duan et al., 2024), to fully mobilize students' learning enthusiasm and initiative. The organizational form of BL was mainly a three-stage model: pre-class, in-class and post-class (Ding et al., 2023; Y. R. Li et al., 2023).

Most of the non-BL groups employed traditional face-to-face learning, while in four studies, the non-BL group used online learning (Losa-Iglesias et al., 2023; McCutcheon et al., 2018; Moon and Hyun, 2019; Park and Yi, 2023). The duration of interventions in quasi-experimental and randomized controlled trials ranged from two hours to three semesters.

4. Discussion

4.1. The number of publications showed an increasing trend year by year, but the regional distribution varied greatly

To avoid confusing the concepts of BL with flipped classroom, this review excluded literature on flipped classrooms that may not involve online learning elements. After a systematic search, 54 studies were included in this review. Compared with previous reviews, such as 26 studies by Niu et al. (2023), 25 studies by Du et al. (2022) and 21 studies by Kanika and Kaur (2020), this review covered a broader range of research on BL in nursing education. The number of studies on BL has increased steadily since 2018, with a sharp rise in 2023, reflecting its growing popularity as an emerging research field expected to attract more attention in the coming years.

China, Republic of Korea, United States of America made the most significant contribution. This can be attributed to their rapid educational informationization (Ashraf et al., 2021) and the government's policies to support and promote the application of BL (Jun, 2012; Lim and Graham, 2021; Owston, 2013). These have further promoted the practice and development of BL in the field of higher education and also explained why BL has garnered so much attention from the academic community in these countries.

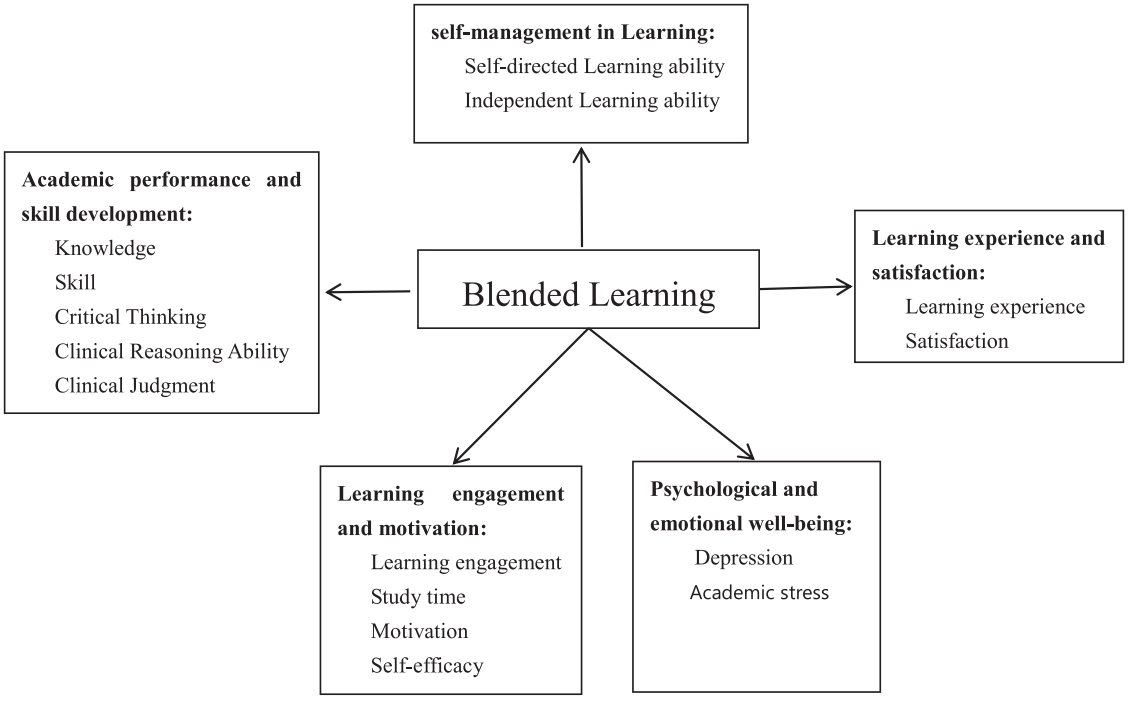


Fig. 4. The model of effects of BL on nursing education.

4.2. The effects of BL

Overall, the effects of BL in various aspects of nursing education are positive, which can be mainly divided into five categories. Based on this, we constructed a model (details see Fig. 4.) to intuitively show the comprehensive effects of BL in nursing education, which is broader and more comprehensive than the results of previous reviews on the effects of BL. In addition, this study discovered the research trends of BL in nursing education, identified some research gaps worth addressing and provided future research directions.

4.2.1. The effects of BL in nursing education are positive and multidimensional, but some effects of BL still need to be further explored

Firstly, as mentioned above, the mainstream result was that BL significantly improved the nursing students' theoretical knowledge level and skills, learning engagement and motivation, self-management, mental health and learning experience and satisfaction. Some of the results were consistent with those of previous systematic reviews and meta-analyses (Du et al., 2022; Niu et al., 2023). The positive effects of BL on nursing students can be explained by the following: (1) BL is student-centered and provides students with a self-directed learning environment and personalized learning paths by integrating online and offline learning. (2) BL provides students with rich learning resources through online simulations and online videos, especially for the acquisition of clinical skills by nursing students. Students can watch the videos repeatedly through online platforms, thus improving their skills. (3) BL provides more practice opportunities and feedback mechanisms through online and offline interactions, which enhances the interaction between teachers and students, motivates students to actively engage in learning and helps understand, consolidate and internalize knowledge (Du et al., 2022).

In addition, critical thinking ability is the ability to effectively solve problems, perform logical reasoning and analyze information before forming conclusions (Lee et al., 2017), which is essential for safe and efficient nursing practice (Papathanasiou et al., 2014). Studies showed BL could significantly improve critical thinking ability compared with traditional teaching (Cao et al., 2021; Park and Yi, 2023), which may be attributed to the focus of BL on teaching higher-level thinking skills such as the integration and application of knowledge rather than memorization (Rahmi and Azrul, 2022; Zhu and Tahir, 2023). Clinical reasoning, crucial for accurate nursing diagnosis and intervention (Forsberg et al., 2014) and clinical judgment, key for informed nursing decisions (Oh, 2019), are also vital competencies for nursing students and can be improved through BL. The above abilities are all clinical thinking abilities that nursing students must possess. However, most studies focused on critical thinking, with fewer on clinical reasoning ability and clinical judgment ability. Therefore, exploring the comprehensive impact of BL on nursing clinical thinking ability is an important direction for future research.

Secondly, mental health plays a key role in influencing student development (Chu et al., 2023; Zhang et al., 2024). It has been reported that nursing students have a higher prevalence of anxiety, depression and stress (Aloufi et al., 2021; Amadu et al., 2024; Chung et al., 2022) and have higher levels of these stress and anxiety than the general student body (Bartlett et al., 2016). Poor mental health among nursing students is common, and it has been widely recognized as an important public health issue (Stubin and Hargraves, 2022). Therefore, nursing educators should pay attention to the mental health of nursing students and take measures to improve their mental health. BL may be an effective solution. According to self-determination theory, individual well-being generally depends on satisfying three basic psychological needs: autonomy, competence and relatedness (Lataster et al., 2022). A study byWong (2022) found that the constructs of relatedness and competence of students' basic psychological needs were fulfilled in the current state of blended learning. For example, studies have shown that BL can reduce depression (Losa-Iglesias et al., 2023) and stress levels (Gerdprasert et al., 2011) among nursing students. This may be related to the interactions and continuous and immediate feedback in the BL environment, which provide students with more emotional support and social opportunities, satisfying their basic psychological needs regarding relatedness and competence. However, the existing empirical evidence on the effect of BL on mental health indicators appears to be inconsistent. For example, Gerdprasert et al. (2011) found that BL can reduce academic stress, whereas Losa-Iglesias et al. (2023) found no such effect. Additionally, research on the effect of BL on psychological and mental health is rare, and they thus far only investigated the effects of BL on nursing students' depression, anxiety, stress, self-esteem and resilience (Losa-Iglesias et al., 2023). Given the inconsistent findings and scarcity of research, more research is needed to verify further the effect of BL on mental health indicators such as stress and to explore the effect of BL on other indicators of psychological well-being or mental health.

Additionally, as highlighted previously, there are inconsistent results on the effects of BL on various variables in nursing education, such as academic performance, learning engagement, self-efficacy, mental health and learning satisfaction. The contradictory findings may be attributed to several factors, such as: (1) Variations in the application of BL: The design and implementation of BL vary significantly between studies (Yu et al., 2021) and curriculum adjustments were made each semester based on student feedback, course evaluations and maintenance of academic integrity, which inevitably affected the results (Berga et al., 2021; Yu et al., 2021). (2) Differences in research design and methodology: The studies we reviewed employed diverse research designs, including randomized controlled trials, quasi-experimental studies, each with varying levels of rigor and control over confounding variables. Furthermore, differences in sample size, sample source, and participant demographics may contribute to divergent findings, such as in Grønlien et al. (2021) and Perez et al. (2022) studies, where the groups were from two cohorts from different semesters. Additionally, unmeasured differences in teaching methods and teaching styles may affect results (Berga et al., 2021). (3) Statistical analyses and measures: The choice of statistical methods and the variables measured can affect conclusions. For instance, in Losa-Iglesias et al. (2023) study, the authors used the Beck Anxiety Inventory, the Beck Depression Inventory and the Academic Stress Coping Scale, while other studies used specific COVID-19 Anxiety and Perception of Academic Stress scales (Berdida and Grande, 2022). (4) Duration of the Intervention: The duration of BL interventions ranged from a few weeks to several semesters across studies. Short interventions may not provide sufficient time for students to adapt and benefit fully from BL, whereas longer duration might lead to disengagement or fatigue, impacting the results negatively (Berga et al., 2021; Liu et al., 2021).

In addition, it may also be related to the instructor's level of competency, preference and experience in teaching (Alshawish et al., 2021; Huang et al., 2021). In the early stages of blended learning, students may need more transition time and adaptation (Blissitt, 2016; Gagnon et al., 2013), which affects the effect.

These inconsistent results may mean that BL has effects on these variables in some cases, but not in other cases. Based on this, we believe that future research can explore "for whom" or "when" BL has an effect or no effect on these variables. Also, notably, most studies on the effects of BL in nursing education lack theoretical foundation. Of the 54 articles reviewed, only 10 were grounded in established theories, such as constructivist theory (Alshawish et al., 2021; Lv et al., 2024), the Community of Inquiry (CoI) framework (Liu et al., 2021; Siah et al., 2021) and connectivist learning theory (Zhang et al., 2022). To foster more meaningful academic discussions, it is recommended that future study or discussion of variable relationships be grounded in relevant theories.

Finally, we found that the intervention duration ranged from 2 hours to 3 semesters. Niu et al. (2023) pointed out that when the intervention duration was longer than 10 weeks, BL did not improve nursing students' knowledge and skills. However, their findings should be

interpreted with caution, because 11 of the 26 articles in their study focused on "Flipped Learning" not BL. Additionally, Li and Wang (2022) found that in K-12 settings, BL interventions lasting less than one semester were more effective than those lasting longer than one semester. Accordingly, it is valuable for future study to determine the optimal intervention duration to more accurately assess the effects of BL.

4.2.2. *Research design and methods needed to be retained and improved*

We identified some trends regarding research design and methods. Firstly, the most used research design is quasi-experimental study, followed by randomized controlled trials (RCTs). Due to the particularity of educational research, it is difficult to achieve complete randomized control (Du et al., 2022), but the results of randomized controlled trials are more credible. Therefore, in future studies, it is recommended to apply more randomized controlled trials. The sampling method determines the representativeness of the sample. Scholars emphasize that research results are only generalizable when samples are randomly drawn from the target population using probability sampling (Sarstedt et al., 2018). Additionally, most studies included in the review used convenience sampling, and some did not specify the sampling methods, which impacted the generalizability of the findings. Most existing studies relied on samples from single sources, such as only one nursing university or college and had small sample sizes. Therefore, future research should employ random sampling and samples from diverse backgrounds to generate more generalizable results.

4.3. *Limitations*

Several limitations should be acknowledged. Firstly, the review only included studies published in English, potentially excluding relevant research in other languages. Additionally, we limited our review to peer-reviewed journal articles, omitting conference papers and other grey literature, which may offer valuable insights. The heterogeneity of studies in terms of research design, sample size, intervention duration and outcome measures made it difficult to compare results comprehensively, potentially affecting generalizability. Many studies relied on convenience sampling, introducing selection bias and the lack of sufficient randomized controlled trials (RCTs) limits the ability to establish stronger causal relationships. Finally, despite a rigorous search strategy, some relevant studies may have been missed. Addressing these limitations in future research will be crucial to strengthening the evidence base for BL in nursing education.

5. Conclusions

In conclusion, while this review highlights the multifaceted benefits of BL in nursing education, it also underscores the urgent need for further research to address existing gaps and inconsistencies. Future studies should prioritize randomized controlled trials to strengthen the evidence base, focusing on the effects of BL on critical areas such as mental health, clinical thinking ability. Additionally, more research is needed to explore the conditions under which BL is most effective, including factors such as intervention duration, student characteristics and institutional support. By addressing these critical areas, future research can ensure that BL fully realizes its potential to enhance nursing education and meet the evolving demands of healthcare.

Ethics declaration

The authors declared that the study is based on publicly available data, theoretical models and open-source data and as such, the nature of this study did not warrant a review by an ethics committee.

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CRediT authorship contribution statement

Ruowei Wang: Writing – original draft, Methodology, Formal analysis, Data curation. **Arumugam Raman:** Writing – review & editing, Validation, Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.nepr.2024.104238.

Data availability

Data generated or analyzed during this study are available from the authors on request.

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