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Enhancing educational through blended teaching: an analysis of teaching and learning quality with learning environment and social impacts

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This paper delves into the challenges and opportunities associated with blended teaching, while analyzing its impact on teaching and learning quality through quantitative methods. It highlights that Blended teaching, fueled by modern educational technologies, holds the potential to significantly enhance teaching standards and student engagement. However, the hybrid model is still in its nascent stages in many contexts, confronting issues such as teaching quality, student adaptation, management mechanisms. The paper provides suggestions for reform, including strengthening teacher training, modifying learning behaviors, expanding supervision, and incorporating sustainable practices. Through practical research, it concludes that Blended teaching can improve student satisfaction, academic performance, and promote the sustainable development of education, emphasizing the need for continuous innovation and improvement in educational practices to fully harness its potential.

KEYWORDS

educational practice, development of education, distance education and online learning, improving classroom teaching, data science applications in education

1 Introduction

The rise of the Internet era has revolutionized education, transcending the limitations of traditional teaching methods. The integration of Blended teaching, driven by modern educational technologies, has emerged as a crucial catalyst for educational innovation, setting new standards and paradigms for university instruction (Lai et al., 2024). As we navigate the educational landscape, there is an urgent need to optimize Blended teaching methodologies and improve teaching quality within the digital environment, which has become a focal point of academic research in higher education institutions (Yang and Lay, 2024). Moreover, the integration of sustainable practices in education is gaining prominence, emphasizing the importance of minimizing the environmental footprint of educational activities.

Blended teaching, the fastest-growing instructional model in North America and globally, leverages the expanded opportunities for teaching and learning by integrating resources and overcoming the constraints of time and space (Archibald et al., 2021). By combining the strengths of traditional in-person instruction with the digital realm of online teaching, educators can innovate, enhance curricula, and raise teaching quality, while also promoting sustainable practices to mitigate the negative impact of education.

However, in many countries, the hybrid teaching model is still in its early stages, with educators having only a vague understanding of its pedagogical nuances. There is a lack of

comprehensive theoretical exploration and systematic research content, presenting numerous challenges that need to be addressed. Therefore, building on previous research, this paper examines the importance of implementing Blended teaching with a focus on sustainability. Through quantitative analysis, it concludes that the adoption of Blended teaching can not only enhance education quality but also contribute to sustainable education practices.

2 The development of the blended teaching model

Initially, the Sloan Consortium in the United States defined "Blended teaching" as a combination of face-to-face instruction with online teaching, integrating two historically separate pedagogical paradigms: traditional in-person education and digital learning (Williams, 2008). Blended teaching represents a new educational paradigm that diverges from the traditional classroom setup. It utilizes modern instructional technologies to seamlessly integrate teaching resources, combining online digital instruction with traditional in-person teaching. Following 2010, as the concept of Blended teaching evolved, theories of "reinforcement" or "enhancement" emerged, redefining the purpose of Blended teaching. It is no longer viewed as simply a supplement or alternative to in-person teaching but rather as a catalyst to invigorate, enhance, and refine the impact of classroom learning.

With the exponential growth of the Internet and advancements in information technology, the concept of Blended teaching has been further expanded under the "Internet +" initiative since 2013. The definition of Blended teaching has evolved to encompass a "learning environment that utilizes mobile communication devices, networked learning spaces, and classroom discussions." During this phase, educators shifted their focus from a technology- and teacher-centric approach to one that is student-centric. The emphasis has been redirected towards creating immersive, personalized learning experiences that actively engage students, emphasizing a harmonious blend of teaching and tutoring within an environment that places students at the center of the educational process (Hoic-Bozic et al., 2016). In order to fully harness Courses (MOOCs), video conferencing platforms like Tencent Meeting, and ubiquitous communication apps including QQ and WeChat, have greatly facilitated the rapid advancement of online teaching methodologies. These tools have played a crucial role in providing strong support for the hybrid teaching model, allowing for a more integrated and dynamic educational experience that goes beyond the limitations of traditional classroom settings.

3 Problems in blended teaching

3.1 Teaching quality problems in blended teaching

As an innovative educational approach, Blended teaching continues to be a subject of ongoing exploration and refinement in the field of education. Consequently, there are several areas where educators' understanding of this model could be improved. Firstly, some faculty members may mistakenly view Blended teaching as simply a combination of online and offline instruction, potentially even as interchangeable components (Asghar et al., 2022). This misconception overlooks the nuanced integration that Blended teaching entails. Secondly, within the hybrid framework, interactions between teachers and students occur within the virtual expanse of cyberspace. During online sessions, teachers are often limited to observing students' engagement through video feeds, which may not fully capture the depth of their responses to the material presented. For educators less adept with digital pedagogy, there is a risk of adhering rigidly to traditional lesson plans, which can hinder a comprehensive understanding of students' learning trajectories and impede meaningful interaction and dialogue. Thirdly, the quality of online teaching resources is a critical element. Without high-quality resources tailored to individual student needs, the advantages of online components may not be fully realized, potentially diminishing the effectiveness of the Blended teaching experience. Subpar resources can lead to lackluster student engagement, fostering boredom and reducing eagerness to learn—ultimately impacting overall education quality provided.

3.2 Students' adaptation in blended teaching

Learning motivation has always been a central focus in the field of education, as it is closely tied to students' academic advancement and the attainment of expected results (Li et al., 2022). It is crucial to acknowledge that students' academic performance is influenced by the interaction between teaching and learning processes (Torres-Coronas and Vidal-Blasco, 2019). In the context of Blended teaching, individual differences among students become prominent, shaped by various factors such as their levels of enthusiasm, patterns of physical and cognitive development, and stages of maturity. As a result, the degree to which students adapt to the educational environment and embrace new teaching methods varies significantly in this Internet-driven era and can even lead to polarization. On one hand, students with strong adaptability skills are likely to make use of their free time for online self-study in line with their teachers' learning objectives. They actively engage in classroom activities, thereby enhancing their overall learning efficiency. Conversely, students who struggle with adaptation may rely heavily on direct teacher instruction. In an online classroom setting, they may find it difficult to regulate their behavior independently, leading to distractions and a lack of engagement. This can manifest as zoning out during lessons or neglecting to follow through on teachers' guidance for self-study. Such behaviors not only hinder immediate learning efficiency but can also have a detrimental effect on long-term academic performance. To address these disparities, it is essential to design Blended teaching experiences that are sensitive to individual differences and provide structured support for students who may be at risk of falling behind. This includes fostering an environment that encourages self-motivation, autonomy, and the development of strong self-regulatory skills, which are critical for success in a Blended teaching context.

3.3 The problem of management mechanism in blended teaching

Students play a central role in the learning process, and their active engagement is essential for the success of Blended teaching initiatives. However, the online component of blended teaching presents unique challenges that can impact student engagement. Research suggests that boys may be more likely to engage in cyberbullying and make inappropriate comments during online interactions (Huang et al., 2020). The virtual nature of online teaching also means that teachers cannot continuously monitor students in real-time, which can lead to potential disciplinary issues. In a physical classroom, Blended teaching relies on students to participate in timely discussions and interactions. Yet, there is a risk that group discussions may veer off-topic, detracting from the learning objectives. Moreover, unfamiliarity with course software can lead to technical mishaps such as audio disruptions when microphones are left open. Excessive background noise can disrupt the classroom order and hinder the learning process.

The challenges extend to online assessments, which carry significant uncertainties. The lack of comprehensive supervision can make it difficult to prevent academic dishonesty such as cheating. For example, in objective tests without timely oversight, students might resort to using other devices to look up answers or share them with peers (Noorbehbahani et al., 2022). To address these challenges, it is crucial to establish clear guidelines and expectations for online conduct, invest in user-friendly course platforms, and implement robust monitoring and assessment strategies. By creating a structured and supportive online learning environment, educators can foster a culture of integrity and academic excellence that upholds the principles of Blended teaching.

4 Suggestions on the reform of blended teaching

4.1 Strengthen teacher training and improve their teaching quality

Advancements in information technology have significantly propelled the growth of online learning (Mayweg-Paus et al., 2021). To refine Blended teaching effectively, it is essential to address and transcend the limitations inherent in teachers' current understanding. Recognizing that Blended teaching encompasses more than just a basic amalgamation of online and offline teaching is crucial; it is about leveraging the synergistic relationship between these two modalities. Concurrently, timely teacher training initiatives should be implemented to enhance the professional image and capabilities of educators within their instructional environments (Huang et al., 2022). Engaging with Blended teaching experts and scholars can enrich teachers' pedagogical ideas and cognitive training, enabling them to grasp the advantages of current hybrid teaching practices (Xie, 2023; Yen and Lee, 2011). This engagement helps teachers expand their instructional perspectives and execute their teaching roles more adeptly.

The online component of Blended teaching has the potential to incorporate a wide range of audio-visual elements, such as video, imagery, sound effects, and multimedia. This not only provides teachers with diverse instructional options but also allows students to fully engage in the learning process, sparking their interest and curiosity. The strategic use of high-quality educational resources, combined with the thoughtful integration of text, image, and sound, can enhance the informational content in the classroom and improve teaching efficiency. Furthermore, this approach can effectively engage students' senses, leading to a deeper understanding of the material and leaving a lasting impression. It stimulates intellectual curiosity, ignites critical thinking processes, and fosters an environment conducive to proactive learning. Such an enriching experience not only enhances overall student learning but also improves teacher instruction quality.

4.2 Changing students' learning behavior and teachers' guidance behavior

The emergence of Internet-based teaching platforms, as highlighted by Bao et al. (2022), provides educators with the opportunity to create an informative instructional environment. Within the Blended teaching framework, teachers can upload their course materials onto these platforms, establishing clear learning objectives and tasks through educational software. This allows students to independently select learning content that aligns with the courseware, enabling them to work towards achieving set goals and tasks. If they encounter any difficulties during their studies, students are encouraged to engage in spontaneous discussions on the platform, sharing their queries and insights. Teachers then provide targeted guidance based on the issues raised, assisting students in navigating through their challenges. This interactive online dynamic transforms students from passive recipients into active participants in their learning journey, fostering a heightened interest in learning and strengthening critical thinking skills. Educators can offer personalized guidance by observing students' classroom behaviors, aiding them in developing effective learning strategies and enhancing adaptability, thereby improving the quality of instruction. By entering the classroom equipped with well-defined questions and tasks, teachers can heighten students' awareness of their learning objectives. This approach not only guides students more effectively but also nurtures their capacity for self-directed learning, bolsters adaptability, and elevates overall teaching quality (Lowell, 2024).

4.3 Expand supervision and improve operation methods

During the implementation of Blended teaching, a variety of technological methods can be utilized to monitor students' learning progress. In terms of course assessments, it is recognized that online exams may lack the capacity to effectively supervise students' responses. Therefore, a hybrid assessment system combining online and offline evaluations can be implemented to deter academic dishonesty. Following the completion of a teaching segment, educators are able to promptly assess the extent of students' knowledge acquisition through online assessments. Utilizing the instructional

management system, teachers have access to students' test scores and analytics on frequently incorrect questions, enabling them to gather feedback and subsequently devise targeted teaching strategies. These strategies play a crucial role in formulating personalized learning plans for individual students.

It is important to acknowledge that students in the same class may interpret the teacher's actions differently (Goellner et al., 2018). Therefore, teachers can develop a digital repository of homework questions tailored to students' assessment results, identifying and revisiting common errors and challenging topics. This allows students to use their free time for reviewing and practicing homework, thus achieving the goals of review and consolidation. With the help of an online homework platform, teachers can efficiently create, distribute, grade, and analyze assignments. Modern tools can be utilized for intelligent marking and assessment, streamlining teachers' workload and enhancing productivity. This efficiency enables teachers to devote more attention to understanding each student's learning progress, refining their teaching methods, and improving educational quality. In turn, students can fully utilize the online teaching platform to identify and record areas for improvement, enabling targeted study and completion of learning tasks. When encountering difficult problems, students can revisit classroom concepts through instructional videos and course materials provided by teachers, thereby enhancing their problem-solving abilities.

5 Practical research on blended teaching

5.1 The construction of blended teaching model

The practical research on Blended Teaching effectiveness presented in this section was conducted within a 'Data Structures' course offered to second-year undergraduate students in Computer Science, with an average class size of 40 students. This course was selected for the analysis due to its inherent suitability for the blended model: it encompasses theoretical concepts that benefit from in-depth face-to-face explanation and discussion, alongside practical programming components and algorithm visualizations that are well-supported by online platforms for self-paced learning, demonstration, and submission. Furthermore, as a core course with significant enrollment, it presents a tangible context for examining the potential learning environmental sustainability benefits of Blended Teaching (e.g., reducing paper usage for handouts, optimizing lab resource utilization). The students' familiarity with digital tools also provided a relevant cohort for evaluating online engagement and adaptation within the blended framework. This study was used Cronbach's Alpha to demonstrate the rigor of the test. In addition, three variables were used for the study: Satisfaction with blended teaching, Attitudinal dimension and Effectiveness dimension to study. The final results show that the experimental results are in accordance with the normal distribution. This study does not discuss ecology and naturalism in the physical environment.

To meet the evolving demands of society for innovative educational models, educators are embarking on a pioneering path, actively pursuing exploration and innovation in education to usher in a new era (Xinfa et al., 2023). Simultaneously, insights gained from online teaching are effectively leveraged during in-person teaching engagements to enliven the classroom environment and invigorate traditional teaching paradigms with a fresh, innovative approach (Yan et al., 2021).

5.1.1 The transformation of online and offline teaching forms

Within the traditional educational framework, instructional design is traditionally divided into three primary levels: the development of learning activities, the organization of the learning environment, and the planning of media delivery. In recent years, there has been a growing trend where progressive education intersects with Internet technology (Salta et al., 2022). An example of this is the "MOOC+SPOC" hybrid model of instruction, in which educators utilize online platforms to deliver data structure courses through a combination of online and offline methods. This not only simplifies the teaching process for instructors but also significantly enhances students' enthusiasm for learning, thereby optimizing the quality and efficiency of data structure instruction and surpassing the limitations of traditional pedagogical approaches (Lou, 2022).

In the digital age, Blended teaching initiatives are increasingly supported by the Internet and big data platforms, utilizing information technology to enhance the effectiveness of classroom teaching (Yang et al., 2022). This approach combines online and offline teaching through the extensive use of digital tools, allowing educators to better manage the learning process at all stages—before, during, and after class—thereby improving overall educational and instructional standards. Throughout the hybrid teaching process, the strengths of online platforms are utilized to overcome spatial and temporal constraints, integrating closely with big data to create a comprehensive online learning resource platform. This platform offers a wide range of teaching materials that enrich both teacher instruction and student learning experiences. At the same time, traditional teaching plans for offline instruction are refined and adjusted to provide targeted guidance for student learning, helping them overcome educational challenges and ultimately enhancing teaching quality (Zhang et al., 2023).

5.1.2 The implementation process of blended teaching model

The implementation of Blended teaching can be divided into three distinct phases: pre-class, in-class, and post-class activities (Berard and Smith, 2008). During the pre-class phase, educators distribute learning tasks through the Internet and other platforms before the lesson, allowing students to engage in self-directed study and willingly participate in group report composition. The in-class phase is the central segment. Instructors are expected to elaborate on critical and challenging aspects of the curriculum during the lesson, promote communication and discussion among students, enhance classroom interactivity, promptly address student inquiries, and assign homework. After class, it is essential for teachers to engage in a series of interactions, reflect on their

teaching promptly, and improve their instructional quality. Students should diligently complete their homework to reinforce the knowledge acquired during the session. This structured approach not only ensures learning outcomes for students but also maintains the quality of the entire educational process.

Initially, in the pre-class stage, teachers are required to outline learning tasks that are aligned with educational goals. This will prompt students to engage in independent study and discussion, thereby fully leveraging their initiative and autonomy in learning. Subsequently, during the classroom instruction phase, teachers should distill the curriculum content and focus on effective teaching methodologies to prevent didactic overload. At the same time, they should encourage student dialogue and discussion while providing timely feedback and assignments to facilitate the consolidation of learned material. Ultimately, educators should engage in prompt communication, persistently reflect upon their teaching methodologies, and strive for continuous improvement in teaching quality. Students are also encouraged to complete their homework punctually to ensure mastery of the concepts they have been introduced to.

In Blended teaching, maintaining a student-centered approach and fully harnessing students' proactive initiative is crucial. Throughout the learning process, there should be an increased emphasis on self-directed learning scenarios (Zhang et al., 2022). Both before and during class, the teacher's pivotal role is evident in innovating teaching content, guiding students in their learning, and stimulating their interest in learning. This strategy aims to disrupt the conventional teaching model and progressively steer students toward active learning. By doing so, students evolve from passive recipients to active learners, fully realizing their subjective initiative. This transformation also allows teachers to better comprehend the students' learning status and identify areas for improvement, thereby enhancing teaching efficiency.

On the other hand, Blended teaching should capitalize on the convenience and continuity it offers after class. In this model, lectures can be recorded, enabling students to resolve most if not all issues independently by reviewing the course playback post-class. Some scholars have suggested establishing an online platform for student interaction (Morgan and Simmons, 2021). The establishment of such a platform facilitates continuous communication with students and keeps educators updated on their learning progress which can enhance students' learning efficiency and affirm the effectiveness of the teaching methods employed.

5.2 Analysis of student satisfaction in blended teaching

In order to assess the impact of Blended teaching on the quality of teaching and learning. Therefore, we developed a questionnaire. Using Questionnaire Star, we conducted a survey titled "University Students' Satisfaction with Blended teaching," which included an evaluation of teaching and learning effectiveness as well as overall satisfaction with the educational experience. Response options in the survey ranged from "very satisfied" to "satisfied," "mostly satisfied," "dissatisfied" and "very dissatisfied."

As indicated in Table 1, a total of 125 questionnaires were collected, resulting in 117 valid responses after screening out invalid data through credibility validation. The coefficient value obtained from reliability analysis was 0.840, surpassing the critical value of 0.8, indicating high data reliability. In terms of respondent demographics, 46.2% were male and 53.8% were female, meeting the diversity criteria for this survey.

The satisfaction dimensions and their respective sub-dimensions from the questionnaire underwent statistical evaluation using SPSS, employing a one-sample t-test. The analysis focused on the average ratings and the significance attributed to elements such as classroom instruction, questioning, discussion, testing, answering, laboratory demonstrations, and homework assignments. As shown in Tables 1, 2, the satisfaction dimension exhibited significant variance ($p < 0.01$), while other dimensions did not show significant discrepancies, indicating a high level of student satisfaction with the blended teaching approach. The one-sample t-test results with a p-value of less than 0.01 indicated a meaningful difference. Therefore, educators may prefer the Blended teaching model when selecting pedagogical methods to

TABLE 1 Analysis of satisfaction.

The correlation				
		Satisfaction data dimension	Attitude dimension data	Effect dimension data
Satisfaction Data Dimension	Pearson ss correlation	1	−0.500**	0.383**
	Sig. (two-tailed)		0.000	0.000
	The case number	117	117	117
Attitude dimension data	Pearson ss correlation	−0.500**	1	−0.440**
	Sig. (two-tailed)	0.000		0.000
	The case number	117	117	117
Effect dimension data	Pearson ss correlation	0.383**	−0.440**	1
	Sig. (two-tailed)	0.000	0.000	
	The case number	117	117	117
**At the 0.01 level (two-tailed), the association was significant.				

**Denotes $p < 0.01$, and *denotes $p < 0.05$ and above correlation analysis results also provide basis and guarantee for subsequent research on influencing factors.

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TABLE 2 One sample test.

One sample test						
	Test value = 3					
	t	Degrees of freedom	Sig. (two-tailed)	The average difference	Difference 95% confidence interval	
					Lower limit	Upper limit
Lecture in class	12.145	116	0.000	1.188	0.99	1.38
Ask questions in class	11.267	116	0.000	1.094	0.90	1.29
Discuss in class	12.715	116	0.000	1.214	1.02	1.40
Test in class	12.898	116	0.000	1.239	1.05	1.43
Answer questions in class	12.185	116	0.000	1.256	1.05	1.46
Experiment demonstrates	12.230	116	0.000	1.214	1.02	1.41
Homework assignments	13.350	116	0.000	1.299	1.11	1.49

TABLE 3 Mean value.

Mean value							
	Lecture in class	Ask questions in class	Discuss in class	Test in class	Answer questions in class	Experiment demonstrates	Homework assignments
Average	4.19	4.09	4.21	4.24	4.26	4.21	4.30
The case number	117	117	117	117	117	117	117
The standard deviation	1.058	1.050	1.032	1.039	1.115	1.073	1.053

enhance students' eagerness to learn and improve their academic achievements. The results presented in Tables 1, 3 demonstrate a consistently high level of student satisfaction across all instructional dimensions of the blended teaching model. One-sample t-tests were conducted to compare the mean scores of each instructional activity against a neutral test value of 3 (the midpoint of the Likert scale). All items showed statistically significant differences, with *p*-values less than 0.001. For example, $t(116) = 13.35$, $p < 0.001$ for "homework assignments," with a mean difference of 1.30 (95% Cl [1.11, 1.49]); $t(116) = 12.19$, $p < 0.001$ for "answering questions in class," with a mean difference of 1.26 (95% Cl [1.05, 1.461). Furthermore, Pearson correlation analysis revealed a moderate positive correlation between satisfaction and perceived effectiveness ($r = 0.383$, $p < 0.001$), suggesting that students who reported higher satisfaction also perceived greater academic gains. Conversely, a moderate negative correlation was observed between satisfaction and attitude ($r = -0.500$, $p < 0.001$), potentially reflecting complex motivational dynamics or reverse-coded items. These relationships merit further examination in the discussion section to better understand the psychologicalas we progress through the Blended teaching experience, it is essential to engage in purposeful reflection on instructional strategies and address any emerging challenges within the blended teaching environment. The goal extends beyond refining teachers' educational techniques and enhancing teaching quality; it also aims to invigorate students' intrinsic motivation to learn, empowering them to fulfill their central role in the educational journey.

5.3 Study status analysis of blended teaching students

To gain a deeper understanding of the learning circumstances of students and to effectively implement Blended teaching, a questionnaire survey was conducted with a focus on students' learning enthusiasm and outcomes. The findings suggest that Blended teaching has a positive impact on students' educational experience, enhances their proactive approach to learning, and elevates the quality of teaching.

5.3.1 Survey on students' enthusiasm

Based on the survey findings, 49.6% of students demonstrate a positive attitude towards classroom participation, with 17.6% actively engaging in class activities. The majority of students believe that teaching should foster a harmonious and dynamic classroom environment. Most students are willing to actively participate in educational activities, collaborating with teachers and peers to explore issues and acquire new knowledge. This indicates that the majority of students possess a high level of enthusiasm for participating in classroom learning, and Blended teaching can further enhance their initiative and eagerness to learn.

5.3.2 Student learning effect survey

As indicated in Table 4, a number of students viewed blended teaching as a method to enhance their academic performance. Specifically, 45.6% of the students reported a significant improvement in their academic performance, while 19.2% noted

TABLE 4 The advantages of blended teaching.

Survey content	Response status	Percentage
The advantages of blended teaching	Information is abundant and easily accessible	26.4%
	The learning atmosphere is relaxed and casual	73.6%
	It is beneficial to cultivate self-learning ability	74.4%
	Through the progress bar repeated playback, consolidation of old knowledge	74.4%
	Teachers online answer questions, fast and convenient	60%
	Learn anytime, anywhere, regardless of time and space	56%
	Famous teachers and classes are fully shared	40.8%
	other	12%

a significant decrease. The majority of students (74.4%) believed that the primary advantage of blended teaching was the opportunity for repeated review through progress notes, which facilitated self-learning and reinforced existing knowledge. Additionally, students were able to select their own learning materials from the teaching courseware in order to meet their learning objectives and tasks.

During the learning process, students are encouraged to engage in spontaneous discussions and contribute their questions and ideas to the teaching platform when they encounter any problems. This allows them to receive targeted guidance from teachers, who will address their concerns and help them solve their problems. The use of this online interactive platform transforms students from passive recipients into active participants in the learning process; thereby increasing their interest in learning and enhancing their critical thinking skills. In the blended teaching process, communication between teachers and students is facilitated through videos, which not only serves the purpose of preventing infections but also improves students' learning efficiency.

6 Conclusion

Throughout this study, the intertwined concepts of Blended teaching and Blended Teaching have been central. Blended teaching describes the integrated student experience of acquiring knowledge and skills through both online and face-to-face modalities. Crucially, the effectiveness of this learning paradigm is fundamentally enabled and shaped by Blended Teaching—the pedagogical strategies, resource curation, activity design, and facilitation methods employed by educators. Our findings underscore that high-quality Blended Teaching practices, including enhanced teacher training, adaptive student guidance, and robust management mechanisms, are the essential catalysts for achieving the positive Blended teaching outcomes observed, such as increased student satisfaction, engagement, and academic performance. This synergistic relationship between effective teaching and engaged learning lies at the heart of realizing the full potential of the blended model for educational sustainability.

Blended teaching empowers educators to fully leverage educational resources, thereby improving their ability to manage and optimize the learning process across pre-class, in-class, and post-class activities. This flexibility allows teachers to dedicate more time to curriculum design aimed at fostering student capabilities and competencies, ultimately elevating the quality of education. Furthermore, by providing convenient access to abundant learning materials via the internet, Blended teaching stimulates students' proactive learning initiatives. This mode of instruction encourages students to engage actively with the material, collaborate with peers, and seek targeted guidance from teachers when needed. Such an interactive and personalized learning environment not only enhances students' academic performance but also cultivates their critical thinking and self-learning abilities. Importantly, Blended teaching contributes significantly to educational sustainability. By reducing paper consumption and commuting emissions, it mitigates the environmental footprint of educational activities. Additionally, by promoting equitable access to quality education, it addresses social sustainability issues, ensuring that all students, regardless of their geographical location or economic background, have the opportunity to thrive academically. The results presented in Tables 1, 3 demonstrate a consistently high level of student satisfaction across constructional dimensions of the blended teaching model. In addition to significance testing, Cohen's d was calculated to assess effect sizes, and all items demonstrated large practical effects (e.g., $d = 1.23$ for homework assignments, $d = 1.13$ for answering questions in class, $d > 1.00$ across literals). These large effect sizes indicate that the differences are not only statistically significant but also educationally meaningful, confirming robust student satisfaction with the blended model in aspects such as interaction, feedback, active learning. In addition to significance testing, Cohen's d was calculated to assess effect sizes, and all items demonstrated large practical effects. These relationships merit further examination in the discussion section to better understand the psychological factors influencing learner experience in blended teaching contexts.

Acknowledging the limitations of this study, such as the presence of invalid data in the survey and the scope of the literature review, future research should aim to address these shortcomings through continuous enhancement and exploration. As Blended teaching continues to evolve, it is imperative that educational institutions invest in both technological infrastructure and teacher training in order to fully harness its potential for promoting sustainable education practices.

In conclusion, Blended teaching represents a promising pathway towards more sustainable and effective educational systems. By balancing the advantages of online and offline teaching, it not only enhances the quality of education but also contributes to environmental and social well-being, aligning with the goals of sustainable development.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

TX: Resources, Supervision, Writing – review & editing. YX: Writing – review & editing. HG: Conceptualization, Data curation, Formal analysis, Investigation, Resources, Supervision, Validation, Writing – original draft. SY: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft. WY: Writing – original draft, Writing – review & editing.

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References

Archibald, D., Graham, C., and Larsen, R. (2021). Validating a blended teaching readiness instrument for primary/secondary preservice teachers. *Br. J. Educ. Technol.* 52, 536–551. doi: 10.1111/bjet.13060

Asghar, M., Afzaal, M., Iqbal, J., and Sadia, H. (2022). Analyzing an appropriate blend of face-to-face, offline and online learning approaches for the in-service vocational teacher's training program. *Int. J. Environ. Res. Public Health* 19:10668. doi: 10.3390/ijerph191710668

Bao, Y., Zheng, H., and Zhao, Q. (2022). Development and practice of mobile internet experimental platform system. *J. Internet Technol.* 23, 407–414. doi: 10.53106/160792642022032302019

Berard, K., and Smith, R. (2008). Evaluating a positive parenting curriculum package: an analysis of the acquisition of key skills. *Res. Soc. Work. Pract.* 18, 442–452. doi: 10.1177/1049731508318656

Goellner, R., Wagner, W., Eccles, J., and Trautwein, U. (2018). Students' idiosyncratic perceptions of teaching quality in mathematics: a result of rater tendency alone or an expression of dyadic effects between students and teachers? *J. Educ. Psychol.* 110, 709–725. doi: 10.1037/edu0000236

Hoic-Bozic, N., Dlab, M., and Mornar, V. (2016). Recommender system and web 2.0 tools to enhance a blended learning model. *IEEE Trans. Educ.* 59, 39–44. doi: 10.1109/TE.2015.2427116

Huang, C., Zhang, S., and Yang, S. (2020). How students react to different cyberbullying events: past experience, judgment, perceived seriousness, helping behavior and the effect of online disinhibition. *Comput. Hum. Behav.* 110:106338. doi: 10.1016/j.chb.2020.106338

Huang, R., Zheng, H., Duan, T., Yang, W., and Li, H. (2022). Preparing to be future early childhood teachers: undergraduate students' perceptions of their identity. *Asia Pac. J. Teach. Educ.* 50, 515–533. doi: 10.1080/1359866X.2022.2066506

Lai, L., She, L., and Li, C. (2024). Online teaching model in the context of blended learning environment: experiential learning and TAM. *Educ. Inf. Technol.* 29, 17235–17259. doi: 10.1007/s10639-024-12465-w

Li, Q., Jiang, Q., Liang, J., Pan, X., and Zhao, W. (2022). The influence of teaching motivations on student engagement in an online learning environment in China. *Australas. J. Educ. Technol.* 38, 8–20. doi: 10.14742/ajet.7280

Lou, Y. (2022). Construction of the human-computer interaction model of hybrid course based on machine learning. *Math. Probl. Eng.* 2022, 1–10. doi: 10.1155/2022/5836710

Lowell, B. (2024). The student hat in professional development: building epistemic empathy to support teacher learning. *Sci. Educ.* 108, 581–607. doi: 10.1002/sce.21848

Mayweg-Paus, E., Zimmermann, M., Le, N., and Pinkwart, N. (2021). A review of technologies for collaborative online information seeking: on the contribution of collaborative argumentation. *Educ. Inf. Technol.* 26, 2053–2089. doi: 10.1007/s10639-020-10345-7

Morgan, B., and Simmons, L. (2021). A "PERMA" response to the pandemic: an online positive education programme to promote wellbeing in university students. *Front. Educ.* 6:642632. doi: 10.3389/feduc.2021.642632

Noorbehbahani, F., Mohammadi, A., and Aminazadeh, M. (2022). A systematic review of research on cheating in online exams from 2010 to 2021. *Educ. Inf. Technol.* 27, 8413–8460. doi: 10.1007/s10639-022-10927-7

Salta, K., Paschalidou, K., Tsetseri, M., and Koulougliotis, D. (2022). Shift from a traditional to a distance learning environment during the COVID-19 pandemic university students' engagement and interactions. *Sci. & Educ.* 31, 93–122. doi: 10.1007/s11191-021-00234-x

Torres-Coronas, T., and Vidal-Blasco, M. (2019). MOOCs and blended teaching models. A practical approach. *Ried-Rev. Iberoam. Educ. Distancia* 22, 325–343. doi: 10.5944/ried.22.2.24093

Williams, J. (2008). The handbook of blended teaching: global perspectives, local designs. *Acad. Manag. Learn. Educ.* 7, 132–133. doi: 10.5465/amle.2008.31413871

Xie, B. (2023). Modified GRA methodology for MADM under triangular fuzzy neutrosophic sets and applications to blended teaching effect evaluation of college English courses. *Soft. Comput.* 2023:7. doi: 10.1007/s00500-023-08891-6

Xinfa, T., Yifei, S., Chenhui, Z., Lihong, W., and Yan, L. (2023). Research on the promotion of digital teaching and learning toward achieving China's dual-carbon strategy. *Front. Environ. Sci.* 11:983526. doi: 10.3389/fenvs.2023.983526

Yan, R., Wang, L., Liu, L., Li, X., Zhou, B., Jiang, N., et al. (2021). A preliminary study on the mixed teaching of human parasitology based on MOOC resources and the experimental teaching digital platform. *Zhongguo xue xi chong bing fang zhi za zhi* 33, 74–78. doi: 10.16250/j.32.1374.2020213

Yang, Y., and Lay, Y. (2024). What are the roles of positive psychological construct in blended learning contexts? Integrating academic buoyancy into the Community of Inquiry framework. *Front. Psychol.* 15:1354156. doi: 10.3389/fpsyg.2024.1354156

Yang, Y., Ouyang, T., Zhang, L., and Wang, J. (2022). Study on blended teaching mode and its application based on the ARCS motivational model: taking bioinformatics course as an example. *Medicine* 101:e30801. doi: 10.1097/MD.0000000000030801

Yen, J., and Lee, C. (2011). Exploring problem solving patterns and their impact on learning achievement in a blended learning environment. *Comput. Educ.* 56, 138–145. doi: 10.1016/j.compedu.2010.08.012

Zhang, X., Zhang, B., and Zhang, F. (2023). Student-centered case-based teaching and online-offline case discussion in postgraduate courses of computer science. *Int. J. Educ. Technol. High. Educ.* 20:6. doi: 10.1186/s41239-022-00374-2

Zhang, J., Zhou, Y., and Li, Y. (2022). Effects of an interaction and cognitive engagement-based blended teaching on obstetric and gynecology nursing course. *Int. J. Environ. Res. Public Health* 19:7472. doi: 10.3390/ijerph19127472