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Development and validation of a blended learning perception scale for higher vocational students

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Abstract

Blended learning, a pedagogical approach that seamlessly integrates online and offline teaching methods, has evolved into a pivotal component of higher education. In order to assess students' perspectives on their experiences with blended learning in higher vocational schools, we developed a comprehensive tool known as the Blended Learning Perception Scale (BLPS). The scale's reliability and validity have been rigorously substantiated through data obtained from 600 students enrolled in a vocational school in China. The creation of this scale primarily entailed the application of quantitative methodologies, including both exploratory and confirmatory factor analyses. The final scale encompasses 24 items, categorizing student perceptions into five distinct factors: content coherence, interaction effectiveness, platform functionality, learning motivation, and learning satisfaction. Collectively, these factors elucidate 68.346% of the total variance. Moreover, the Cronbach's coefficients (α) for these factors range from 0.791 to 0.842, denoting a high degree of internal consistency and thereby establishing the scale's reliability. Item-based analysis further substantiates the scale's reliability and discriminability, while confirmatory factor analysis unequivocally confirms its structural validity. Each factor's average variance extracted (AVE) ranges from 0.589 to 0.671, with a cumulative value of 2.766. Additionally, the Root Mean Square Error of Approximation (RSMEA) recorded at 0.053 underscores the scale's satisfactory level of structural validity. In essence, this study presents a valid and dependable instrument for gauging students' perceptions of blended learning, thoughtfully tailored to the specific attributes of higher vocational education and its students. Furthermore, it offers insights into the areas that necessitate further enhancement within blended learning programs.

Keywords: Blended learning, Higher vocational education, Student perception, Scale development

Introduction

The educational landscape is undergoing profound transformations, with teaching and learning extending far beyond the confines of traditional classrooms (Marold et al., 2000). The conventional in-person teaching methods were significantly disrupted during and after the COVID-19 pandemic when social distancing measures became the "new normal," leading to a surge in online-based instruction (Kohnke et al., 2023). Consequently, the concept of blended learning, which seamlessly integrates both online and offline elements into the educational process, has gained substantial traction (Bhagat et al., 2023). Over the past three decades, it has evolved into a pivotal component of higher education and, when well-conceived and effectively implemented, holds the potential to revolutionize established educational paradigms (Garrison & Vaughan, 2008; Yan et al., 2023).

Published research on blended learning has predominantly centered on its definition, implementation models, and its impact on education. The definition of blended learning is fluid, continually evolving to adapt to the changing educational landscape (Graham, 2006). Broadly speaking, it refers to an instructional approach that seamlessly integrates face-to-face and computer-assisted online instruction, encompassing learning activities in both physical and virtual spaces (Alammary et al., 2014; Graham et al., 2013). A typical blended learning program may involve several stages, including face-to-face teacher guidance, collaborative in-person student interactions, online teaching, self-paced online learning, and student online collaboration (Evans et al., 2020; Jen & Hoogeveen, 2022; McCarthy & Palmer, 2022). Blended learning is widely seen as a highly promising instructional approach, offering students flexibility, interactivity, and sustainability (Rasheed et al., 2020). Implementations and research have consistently affirmed its effectiveness in enhancing learning outcomes. Engagement in blended learning programs has not only elevated academic performance (Fisher et al., 2021; Law et al., 2019; Zhang et al., 2015) but has also positively impacted learning motivation and attitudes (Acosta-Gonzaga & Ramirez-Arellano, 2021; Ashraf et al., 2022; Wong et al., 2020), course satisfaction (Alshehri, 2017; Um et al., 2021), and student self-efficacy (Heo et al., 2022; Vanslambrouck et al., 2019). Moreover, a blended learning environment is associated with more effective teacher instruction, offering greater opportunities for practice and prompt, formative feedback (Medeiros et al., 2018).

The student's perception of their blended learning experience plays a pivotal role in their overall engagement with the learning process (Manwaring et al., 2017). However, research on the evaluation of blended learning from the perspective of student perception remains relatively limited (Kurt & Yıldırım, 2018; Wang et al., 2021). Notably, none of the existing efforts to develop and validate measurement scales for assessing student perceptions of blended learning have specifically targeted the realm of higher vocational education. In contrast to university education's focus on academic performance, higher vocational education prioritizes the development and application of vocational skills. Additionally, students in vocational schools often possess distinct knowledge reserves and learning styles (Liang, 2015; Liu & Yang, 2017). These disparities underscore the need to create and validate measurement tools tailored to the unique characteristics of higher vocational education and its students, enabling a more accurate evaluation and refinement of learning designs and implementations.

This study seeks to make a significant contribution to the assessment of blended learning by delivering a robust and valid scale for gauging student perceptions in higher vocational institutions. Moreover, it holds the potential to guide the development and execution of such learning programs by identifying the critical elements that influence student learning experiences. This endeavor is of particular importance in the post-pandemic era, where online instruction has become an inescapable reality, potentially even a mandatory one.

Literature review

Recognizing student perception of a learning program as a significant influencing factor to engagement and effectiveness of learning, a number of scales and questionnaires that focus on student perception have been developed, such as the Curriculum Perceptions Questionnaire (CPQ) (Entwistle & Ramsden, 1983), the Curriculum Experience Questionnaire (Wilson et al., 1997), and the Student Curriculum Experience Questionnaire (Barrie et al., 2005; Ginns et al., 2007). However, these well-established instruments are mainly applicable to traditional classroom-based, face-to-face instruction, and therefore are not suitable for evaluating current higher education programs where the Internet and other web-based technologies have become the integral medium for teacher instruction and student learning (Castle & McGuire, 2010; Han & Ellis, 2020; Singh, 2021).

A survey of literature has rendered a number of scales that specifically measure blended learning. For example, Hsu et al. (2009) developed and validated a 4-dimensional scale that contained 40 items for assessing the quality of blended learning programs supported by a web-based learning platform. Gülbahar and Alper (2014) constructed a scale of proven reliability and validity to measure student e-learning style and its influence on learning effectiveness. This scale consisted of 38 items and examined 7 factors. Xu (2020) designed a 2-tiered scale that explored and evaluated student engagement in both classroom-based learning and online learning. The scale has achieved high reliability, validity, and in-depth analysis of student learning engagement.

There are also some measurements that focus on student perception of blended learning experiences. For example, as early as 15 years ago, a 50-item scale was established that specifically measured student perception of blended learning (Akkoyunlu & Soylu, 2008). To uncover the relationship between students' perception of blended learning courses and their learning achievement as reflected in course grades, Owston et al. (2013) created and applied a 31-item questionnaire that measured how the students perceived their learning experiences in the blended programs from 4 aspects, including the overall satisfaction, convenience afforded, engagement, and views on learning outcomes. Recently, Han and Ellis (2020) developed the Perceptions of the Blended Learning Environment Questionnaire which contained 16 items and involved 3 factors. Bervell et al. (2021) validated the Blended Learning Acceptance Scale, a 45-item and 11-factor scale, to evaluate the acceptance of blended learning integrating distance tutors. Bhagat et al. (2023) constructed a 19-item scale that focused on 3 factors of course design, learning experience, and personal factors.

The measurements of student perception of blended learning reviewed provide important guidance and useful insights for further efforts on assessments of blended learning programs. Nevertheless, none of them have taken the uniqueness and specificities of higher vocational education and students into careful consideration, which awaits further research.

Research purpose and questions

This study endeavors to develop a comprehensive, valid, and psychometrically reliable instrument for evaluating student perceptions of blended learning programs within the context of higher vocational education. This instrument, named the Blended Learning Perception Scale (BLPS), aims to uncover the pivotal factors influencing student perceptions. Employing quantitative methods such as exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), the study answered the two research questions: 1) What are the key elements involved in creating a blended learning perception scale that is specifically tailored to meet the needs of higher vocational students, supported by evidence of validity and reliability? 2) What factors contribute to shaping student perceptions of blended learning programs, and how can these factors be identified to pinpoint areas that could benefit from further enhancement?

Methodology

In this study, a quantitative approach was employed. The initial Blended Learning Perception Scale (BLPS) used to assess student perceptions of blended learning experiences in higher vocational schools was constructed by amalgamating and customizing existing scales designed for evaluating blended or online learning programs. This process was carried out in consultation with subject-matter experts. The reliability and validity of BLPS, as well as the key factors influencing student perceptions, were rigorously examined and affirmed using a combination of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). These analyses were conducted based on data gathered from a substantial sample comprising 600 students.

Participants

The participants were students enrolled in a higher vocational school located in Guangdong province, China. This institution had recognized the advantages of blended learning and had formally mandated that instructors of public courses adopt blended learning as the primary instructional method. To assist teachers in crafting and executing blended learning strategies, the school offered general guidance. For the online component of their learning, the school had chosen the Chaoxing platform (https://www.chaoxing.com/), a widely utilized platform within Chinese higher education institutions. Chaoxing served as the central repository for all instructional materials related to public courses, while also providing tools for interaction between teachers and students.

The research included two batches (300 for each batch) of first-year students, all falling within the age range of 18 to 21, and enrolled at this vocational school. Each participant had prior exposure to blended learning and willingly contributed feedback aimed at improving the design and effectiveness of blended learning programs offered by the school. Every student in both batches completed the constructed scale designed for the study.

The development of Blended Learning Perception Scale (BLPS)

The Blended Learning Perception Scale (BLPS) was refined to comprise a total of 24 items, distributed among five subsets: content coherence, interaction effectiveness, learning satisfaction, platform functionality, and learning motivation (see Appendix 1). These subsets were determined based on a comprehensive review of existing literature. Respondents were tasked with rating the selected items on a five-point Likert scale, ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). The development of the BLPS encompassed several key steps, including the creation of an item bank, data collection, exploratory factor analysis, and confirmatory factor analysis. For a detailed overview of this process, please refer to Figure 1.

Generation of item bank

Stage 1: Selection of initial items. During the initial phase of developing the Blended Learning Perception Scale (BLPS), a meticulous process was undertaken to curate the item bank. This selection process involved a comprehensive review and analysis of existing scales, with specific reference to scales utilized in studies conducted by researchers such as Qin (2017), Wang (2020), Gao (2018), Jiang (2019), and Weinstein et al. (2020).

In the scale developed by Qin (2017), a factor termed “content coherence” comprises 7 items, assessing the extent to which course content in blended learning exhibits logical coherence. The alpha coefficient for this factor is an impressive 0.91. Gao’s (2018) scale introduces an “interaction effectiveness” factor with 7 items, measuring the impact of teacher-student interaction within the classroom setting. The alpha coefficient for this

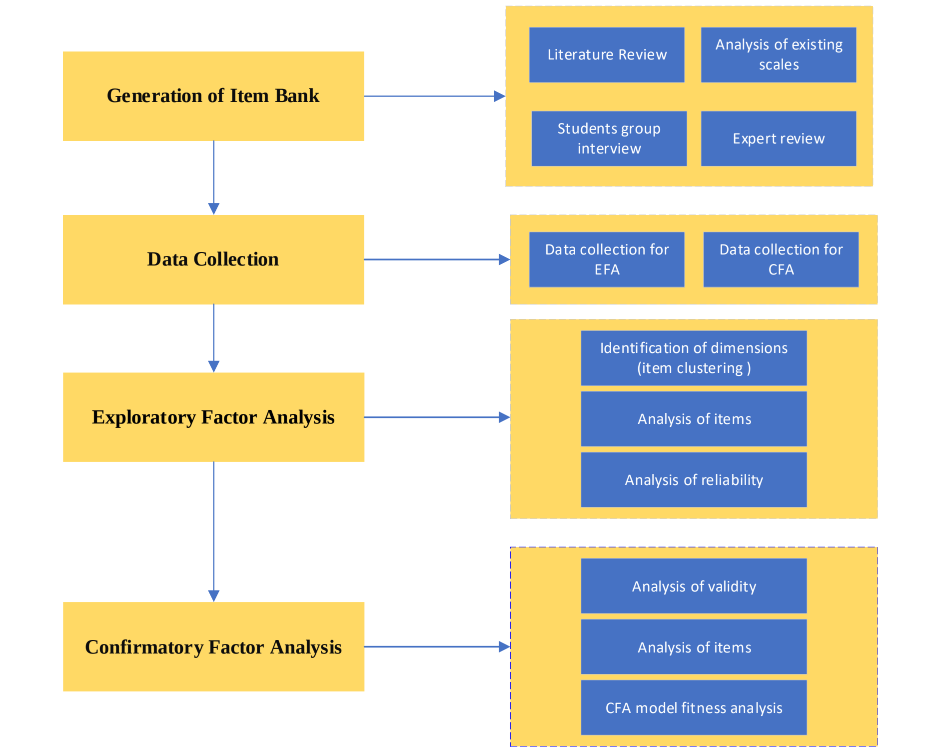

Fig. 1 The BLPS scale development process

factor is a robust 0.94. Wang's (2020) research contributes a "learning satisfaction" factor, consisting of 8 items designed to gauge student satisfaction with various aspects, including the platform, content, and interaction activities in blended learning. The Cronbach's alpha coefficient for this factor is an impressive 0.958. Jiang's (2019) scale introduces a "platform functionality" factor, encompassing 7 items that assess the adequacy of online learning platforms in facilitating various online and offline learning activities. The alpha coefficient for this factor is a commendable 0.96. In Weinstein et al.'s (2020) Learning and Study Strategies Inventory for Learning Online, a "learning motivation" factor is incorporated, comprising 6 items. This factor evaluates the degree of students' responsibility for their learning, their effort invested in mastering course materials, and their persistence in pursuing academic goals, particularly when faced with challenging or less engaging tasks. This factor, therefore, underscores students' diligence, perseverance, and self-motivation, with an alpha coefficient of 0.77. The initial scale was ready in mid-June of 2019.

Stage 2: Pilot test and expert review. In late June 2019, two members of the project team collected a total of 62 valid questionnaires. They employed an exploratory factor analysis using maximum variance rotation. The results revealed that there were seven factors with eigenvalues greater than 1, accounting for a cumulative variance of 66.53%. However, six items within these factors had factor loadings less than 0.4, and they were subsequently removed, leaving 29 remaining items. These remaining 29 items underwent factor analysis with eight iterations for maximum variance convergence. The final results of the factor analysis yielded five factors with eigenvalues greater than 1, explaining 62.45% of the total variation. This formed the basis of the 2019 version. Furthermore, consultations were held with two professors from higher vocational institutions who recommended adding a specific item: “The learning resources on the platform are clearly classified.” This addition brought the total number of items in the scale to 30.

In early January 2020, two members of the project team conducted another pilot test, collecting 112 valid questionnaires. The factor analysis was conducted to use maximum variance rotation, resulting in five factors with eigenvalues greater than 1, explaining a cumulative variance of 63.27%. Three items exhibited factor loadings less than 0.4, and two items had double factor loadings with a difference of less than 0.2 between them. These five items were subsequently removed, leaving 25 remaining items. Continuing with five iterations of factor analysis using maximum variance rotation, the final result yielded five factors with eigenvalues greater than 1, explaining a cumulative variance of 63.21%. This formed the basis of the 2020 version of the scale, consisting of 25 items across five dimensions.

Stage 3: Expert review and student interview. In late June 2022, three vocational education experts were invited to review BLPS. These experts included two professors specializing in higher vocational education from a higher vocational institution and a vocational education research institute, a professor specializing in educational technology in higher vocational education. They have been actively involved in China’s vocational education sector and have contributed to the development of national-level vocational education policies. In their feedback, all three experts highlighted the importance of whether the allocation of content between online and offline components was conducive to the learning of theoretical knowledge and practical skills. Taking this valuable suggestion into account, we refined an item to reflect this concern: “Content distribution of the online course and the offline course is appropriate and conducive to the learning of theoretical knowledge and practical skills.”

Additionally, based on interviews with 20 higher vocational students, where we considered students’ preferences, two points emerged with high frequency: “The course videos on the platform are useful” and “In the process of blended learning, teacher-student interaction and student-student interaction are frequent.” Consequently, we incorporated these points into the BLPS questionnaire.

Through this iterative process, the BLPS was adjusted to comprise a total of 28 items. Simultaneously, some item phrasings were refined. This development process was guided

Table 1 The BLPS item generation process

Stage 1 Selection of initial items			Stage 2 Pilot testing and expert review			Stage 3 Expert review and student interview	
Factor	No. of Items	Source	Pilot test 1	Expert review	Pilot test 2	Expert review	Student interview
Content Coherence	7	Qin (2017)	Six items were removed, leaving 29 items	One item was suggested, leaving a total of 30 items	Five items were removed, leaving 25 items	One item was added, leaving 26 items	Two items were added, leaving 28 items
Interaction Effectiveness	7	Gao (2018)					
Learning Satisfaction	8	Wang (2020)					
Platform Functionality	7	Jiang (2019)					
Learning Motivation	6	Weinstein et al.'s (2020)					
Total	35		29	30	25	26	28

by insights from studies conducted by Garriott et al. (2021), Nikolova et al. (2014), and Kong and Lai (2022). The evolution of the BLPS is summarized in Table 1.

Data collection and analysis

The BLPS underwent a two-phase administration to students in the DGPT program. The data from the first batch were utilized for exploratory factor analysis (EFA), while data from the second batch were employed for confirmatory factor analysis (CFA). Items that exhibited double factor loadings or factor loadings lower than 0.4 were removed, in accordance with the recommendations of Hung (2016) and Siddiquei and Khalid (2021). Moreover, a comprehensive validation process included reliability analysis, validity assessment, and CFA model fit analysis, with insights drawn from research conducted by Chiang et al. (2023) and Hung et al. (2010).

The online survey platform used to collect student responses for the BLPS was wjx.cn (https://www.wjx.cn/), a widely adopted platform in China for conducting surveys. The initial batch of data underwent EFA to discern the scale's underlying structure, while the subsequent batch was subjected to CFA to evaluate its reliability, validity, and overall model fit (Marsh et al., 2009).

Statistical software packages, specifically SPSS 24.0 and Amos 24.0, were employed for a comprehensive analysis encompassing EFA, reliability assessment, item analysis (including correlation analysis and independent sample t-tests), validity testing, and model fitness evaluation. Through these analytical processes, the BLPS was refined, and key factors influencing student perceptions of blended learning experiences were identified. The data analysis would help answer the research questions (Figure 2).

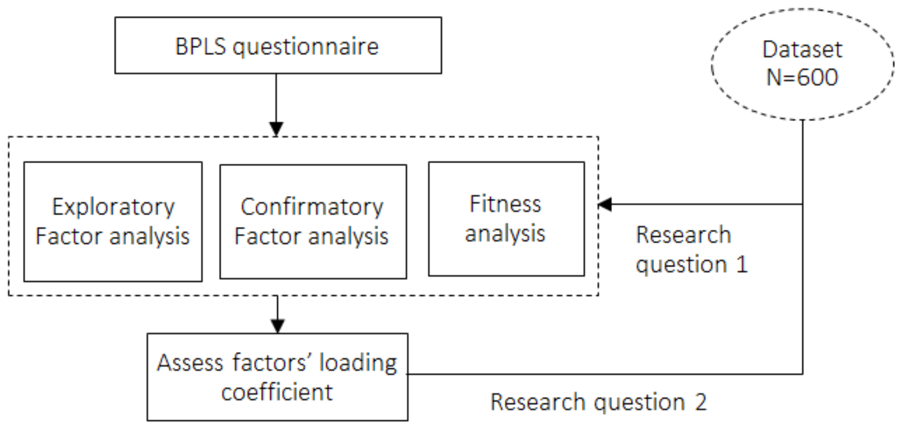

Fig. 2 The data analysis methods

Findings

Exploratory factor analysis

To assess the appropriateness of the gathered data for exploratory factor analysis (EFA), the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's sphericity test were conducted. The outcomes affirmed the suitability of our sample for factor analysis. The KMO value, which was 0.832, surpassed the commonly accepted threshold of 0.5 (George & Mallery, 2001; Hair et al., 1998; Kline, 1994), indicating sample adequacy. Additionally, Bartlett's sphericity test yielded a significant result (χ^2 = 5419.318, df = 259, p < 0.01), further affirming the appropriateness of the data for factor analysis.

Factor analysis

Principal component analysis with varimax rotation was conducted to extract and identify the major factors. Factors with eigenvalues greater than 1 were considered principal factors. In total, five factors were extracted, which accounted for a cumulative variance of 68.346%. The adequacy of the factor structure was verified by examining the factor loadings of each item, and the results are summarized in Table 2.

Within each factor, we applied specific criteria to refine the item selection process. Items that displayed factor loadings below 0.4 or exhibited a double loading (defined as a difference of less than 0.35 between the two highest factor loadings) were eliminated. Additionally, items that lacked a clear semantic alignment with the respective factor were also excluded from the analysis. Following these criteria, a total of four items (Items 7, 10, 13, and 27) were removed from consideration. Items 13 and 27 had notably low factor loadings, measuring at 0.298 and 0.313, respectively, both falling below the 0.4 threshold.

Table 2 Explained total variance (EFA, n = 300)

Compo-sition	Initial eigenvalue			Extract the sum of loads squared			Sum of the squares of rotating loads
	Total	Percentage of variance	Cumulative percentage	Total	Percentage of variance	Cumulative percentage	Total
1	12.185	42.915	42.915	12.185	42.915	42.915	9.350
2	1.628	7.852	50.767	1.628	7.852	50.767	5.352
3	1.235	6.242	57.009	1.235	6.242	57.009	9.156
4	1.211	5.912	62.921	1.211	5.912	62.921	7.251
5	1.106	5.425	68.346	1.106	5.425	68.346	6.285
6	0.830	3.891	72.237				
7	0.736	3.512	75.749				
8	0.655	3.121	78.87				
9	0.601	2.781	81.651				
10	0.561	2.281	83.932				
11	0.504	1.915	85.847				
12	0.478	1.796	87.643				
13	0.433	1.681	89.324				
14	0.382	1.532	90.856				
15	0.356	1.411	92.267				
16	0.324	1.302	93.569				
17	0.297	1.215	94.784				
18	0.271	0.968	95.752				
19	0.245	0.883	96.635				
20	0.212	0.850	97.485				
21	0.183	0.765	98.250				
22	0.145	0.690	98.940				
23	0.131	0.598	99.538				
24	0.118	0.462	100				

Note: Factors were extracted via the principal component analysis method

Furthermore, these two items presented semantic conflicts with other items within the same factor, indicating a lack of meaningful alignment. As for Items 7 and 10, they exhibited double loading issues, with absolute differences between their loadings on two factors measuring at 0.132 and 0.210, respectively. After the exclusion of these four items, our dataset consisted of 24 remaining items, which underwent a second round of exploratory factor analysis (EFA). This subsequent analysis utilized principal component analysis and varimax rotation. The outcomes of this second EFA, along with the items associated with each factor, are summarized in Table 3. In total, five principal factors were identified through this rigorous process.

The first factor extracted was content coherence (CC), which consisted of 5 items that assessed the interconnectedness and consistency of content and goals between online and offline courses, as well as the integration of theoretical knowledge and operational skills. The concept of content coherence is concerned with ensuring that topics are not excessively overlapping, building on prior knowledge, and facilitating the learning of complex topics with basic ones (Confrey et al., 2017). The correctness, consistency, and appropriate sequencing of course content and the connection between content and exercises are important factors in achieving content coherence (Gueudet et al., 2013). Similar to this study, Qin (2017) also identified content coherence as a key factor in blended learning experiences.

Table 3 Second exploratory factor analysis results

Items	Factors				
	CC	IE	PF	LM	LS
18. The content of the online course is connected to the content of the offline course. There is no contradiction or conflict.	0.745				
20. The content between the online course and the offline course is well connected.	0.628				
23. The goals of the online course are the same as those of the offline course.	0.513				
2. Time allocation of the online and offline courses is reasonable.	0.487				
8. Content distribution of the online course and the offline course is appropriate and conducive to the learning of theoretical knowledge and practical skills.	0.456				
5. In the process of blended learning, teacher-student interaction and student-student interaction are frequent.		0.713			
6. In the process of blended learning, teachers supervise students to complete the corresponding learning tasks and provide feedback in a timely manner.		0.629			
15. When students encounter difficulties in learning, teachers give timely help and support.		0.586			
25.The assessments of the course can evaluate student learning comprehensively.		0.478			
28. The interaction function embedded in the platform meets the practical needs.			0.802		
22. I am satisfied with the functional design of the platform.			0.751		
9.The learning resources on the platform are rich and enlightening.			0.629		
21. The learning resources on the platform are clearly classified.			0.543		
26. The course videos on the platform are useful.			0.506		
12. Even when study materials are dull and boring, I keep working until I finish.				0.812	
19. When the task is difficult, I either give up or only complete the easy part.				0.796	
11. When I encounter difficulties in a course, I can motivate myself to complete the work.				0.725	
14. Even if I do not like an assignment, I can motivate myself to work on it.				0.532	
16. I set goals for the grades I want to get in a course.				0.481	
1. I am very satisfied with the content of the online and offline courses.					0.751
3. I am very happy with the way teaching is organized in the blended learning program.					0.651
17. I am very satisfied with the platform for online learning.					0.581
4. I really like the instruction model that combines online and offline teaching.					0.524
24. I think the combination of online and offline teaching is more effective than purely teaching online or offline.					0.493
Variance contribution rate of each factor (%)	9.350	5.352	9.156	7.251	6.285
Cumulative contribution rate (%)	42.915	50.767	57.009	62.921	68.346

The second factor was Interaction effectiveness (IE). It has 4 items that measured whether there were frequent interactions, constant and timely teacher supervision, feedback, and facilitation, and the course assessments could comprehensively evaluate student learning in the blended program. Interaction is an important element of blended learning. In a blended learning session, students may interact with their peers, the instructor, the web-based learning platform, and the learning resources provided (Bonk & Graham, 2012). Interaction effectiveness depends on the smoothness and efficiency of various forms of interaction both online and offline. This factor was consistent with the classroom organization proposed by Gao (2018).

The third factor was platform functionality (PF). 5 items of PE investigated how students perceived the functional design of the platform and the presentation, richness, organization, and usefulness of online resources incorporated. Platform functionality depends on the adequacy of the platform design to address student needs and the quality of learning resources provided (Zhenchenko et al., 2022). This factor echoed the factor of platform perfection proposed by Wan (2017).

The fourth factor was learning motivation (LM). 5 items of LM explored student proactivity and persistence in learning. This factor was basically the same as the learning motivation factor adopted in the Learning and Study Strategies Inventory for Learning Online (Weinstein et al., 2020).

The last factor was learning satisfaction (LS). There were 5 items that evaluated student acceptance and preference of the course content, instructional method, and online learning platform provided in the blended learning program and the perceived effectiveness of this blended approach of learning. Student satisfaction is defined as the “short-term attitudes arising from an assessment of a student’s educational experience, services and facilities” (Alqurashi, 2019). Learning satisfaction is the subjective feeling of students of their learning processes and outcomes (Weerasinghe & Fernando, 2017). This factor was consistent with the factor of learning satisfaction investigated in Gao (2018).

Item analysis

To further evaluate the robustness of BLPS, we conducted item-based correlation analysis and independent sample t-test using the initial dataset of 300 participants. The results of these independent sample t-tests and item-based correlation analyses are presented in Table 4. The correlation coefficients between each item and the total BLPS score exhibited a range of values from 0.434 to 0.791, all of which were statistically significant at the $p < 0.01$ level. Importantly, each item demonstrated a correlation coefficient exceeding 0.4, while concurrently maintaining a p-value below 0.05. This outcome indicates a strong homogeneity between individual items and the overall score, aligning with established criteria for scale soundness (Makransky et al., 2017; Whittaker & Worthington, 2016).

Table 4 Item analysis results

Items No.	Item-based correlation analysis		Independent sample t-test	
	Correlation coefficient	*p*	*t*	*p*
18	0.611	0.000	8.962	0.000
20	0.547	0.000	10.626	0.000
23	0.492	0.000	3.285	0.000
2	0.591	0.000	4.295	0.000
8	0.635	0.000	6.654	0.000
5	0.671	0.000	8.312	0.000
6	0.434	0.000	10.134	0.000
15	0.583	0.000	6.652	0.000
25	0.632	0.000	7.525	0.000
28	0.659	0.000	7.285	0.000
22	0.596	0.000	6.668	0.000
9	0.791	0.000	9.362	0.000
21	0.577	0.000	5.296	0.000
26	0.712	0.000	6.367	0.000
12	0.709	0.000	4.251	0.000
19	0.578	0.000	10.125	0.000
11	0.642	0.000	9.245	0.000
14	0.535	0.000	8.351	0.000
16	0.712	0.000	7.245	0.000
1	0.497	0.000	8.323	0.000
3	0.539	0.000	9.124	0.000
17	0.572	0.000	8.642	0.000
4	0.746	0.000	11.568	0.000
24	0.622	0.000	9.547	0.000

To assess the discriminative capacity of the scale, we formed two groups: a high-scoring group (comprising the upper 27% of the sample) and a low-scoring group (representing the lower 27% of the sample). The results of independent sample t-test revealed significant distinctions between these two groups for each BLPS item ($p < 0.001$). The t-values ranged from 3.285 to 11.568, surpassing the critical ratio (C.R.) value of 3 and yielding *p*-values below 0.05. These findings indicate that each BLPS item possesses strong discriminatory power (Bedford & Deary, 2003).

In summary, the correlation analysis and independent sample t-test confirmed the high degree of homogeneity between individual BLPS items and the total score, as well as the robust discriminative ability of each item. These results collectively support the suitability of the BLPS for subsequent reliability and validity analyses.

Reliability analysis

The reliability of a scale refers to its stability and internal consistency across measurements. In this study, reliability analysis was performed on each factor of the BLPS scale. Cronbach's alpha coefficients were calculated, along with α after item deletion. The results are presented in Table 5, showing that the Cronbach's alpha values for the CC, IE, PF, LM, and LS factors were 0.723, 0.791, 0.826, 0.812, and 0.819, respectively. The overall scale had a Cronbach's alpha value of 0.807. These findings indicate that the BLPS scale is reliable.

Table 5 Reliability analysis results

Latent variables	No.	Measurement index	α after item deleted	α
Content coherence (CC)	CC1	The content of the online course is connected to the content of the offline course. There is no contradiction or conflict.	0.711	0.723
	CC2	The content between the online course and the offline course is well connected.	0.681	
	CC3	The goals of the online course are the same as those of the offline course.	0.712	
	CC4	Time allocation of the online and offline courses is reasonable.	0.702	
	CC5	Content distribution of the online course and the offline course is appropriate and conducive to the learning of theoretical knowledge and practical skills.	0.721	
Interaction effectiveness (IE)	IE1	In the process of blended learning, teacher-student interaction and student-student interaction are frequent.	0.708	0.791
	IE2	In the process of blended learning, teachers supervise students to complete the corresponding learning tasks and provide feedback in a timely manner.	0.773	
	IE3	When students encounter difficulties in learning, teachers give timely help and support.	0.781	
	IE4	The assessments of the course can evaluate student learning comprehensively.	0.724	
Platform functionality (PF)	PF1	The interaction function embedded in the platform meets the practical needs.	0.782	0.826
	PF2	I am satisfied with the functional design of the platform.	0.791	
	PF3	The learning resources on the platform are rich and enlightening.	0.819	
	PF4	The learning resources on the platform are clearly classified.	0.725	
	PF5	The course videos on the platform are useful.	0.821	
Learning motivation (LM)	LM1	Even when study materials are dull and boring, I keep working until I finish.	0.803	0.812
	LM2	When the task is difficult, I either give up or only complete the easy part.	0.701	
	LM3	When I encounter difficulties in a course, I can motivate myself to complete the work.	0.810	
	LM4	Even if I do not like an assignment, I can motivate myself to work on it.	0.799	
	LM5	I set goals for the grades I want to get in a course.	0.753	
Learning satisfaction (LS)	LS1	I am very satisfied with the content of the online and offline courses.	0.749	0.819
	LS2	I am very happy with the way teaching is organized in the blended learning program.	0.761	
	LS3	I am very satisfied with the platform for online learning.	0.812	
	LS4	I really like the instruction model that combines online and offline teaching.	0.801	
	LS5	I think the combination of online and offline teaching is more effective than purely teaching online or offline.	0.789	
Total				0.807

Confirmatory factor analysis

The exploratory factor analysis (EFA) was initially conducted using the first batch of data, resulting in a scale comprising 24 items and 5 factors. Subsequently, a confirmatory factor analysis (CFA) was executed on the second batch of data (n=300) to assess the model's goodness of fit.

Fitness analysis

Several established criteria were applied to evaluate the model's fitness. For the goodness of fit, a value of 3.0 or lower is indicative of a strong fit, while a range between 3.0 to 5.0 is considered acceptable (Hair et al., 2009; Kline, 2004). Furthermore, the goodness of fit indices such as GFI, AGFI, CFI, and NFI greater than 0.90 suggest a good fit, with values surpassing 0.95 indicating an excellent fit. Additionally, values of RMSEA and SRMR smaller than 0.08 signify a good fit, while values less than 0.05 denote an excellent fit (Hu & Bentler, 1999; Iacobucci, 2010). Based on these comprehensive criteria, the 5-factor, 24-item BLPS scale was found to be highly suitable, as confirmed by the results of the fitness analysis (refer to Table 6).

Reliability and validity analysis

To assess the reliability and validity of the BLPS, we employed several well-established metrics, including Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), and discriminant validity (DV). Cronbach's alpha values exceeding 0.7 were indicative of robust internal consistency among the factors. CR, on the other hand, measured the reliability of all items within each individual factor, reflecting the factor's internal consistency. Higher CR values signified stronger internal consistency, with a threshold of 0.7 or above indicating commendable combination reliability (Fornell & Larcker, 1981; Sanchez et al., 2013). AVE gauged the average interrelatedness among the latent variable's items (i.e., the factor). Higher AVE values denoted more substantial convergence among items assessing the same factor. An AVE value surpassing 0.5 was indicative of robust factor validity (Hair et al., 2014), while a value falling between 0.36 and 0.5 was considered acceptable for factor validity (Stylidis et al., 2014). In the CFA model for BLPS, we integrated the factor loadings of each item, along with Cronbach's alpha, CR, and AVE values for each factor. These results are comprehensively presented in Table 7 and visually depicted in Figure 3.

Table 6 Fitness analysis results

	χ^2 / df	GFI	CFI	NFI	IFI	RMSEA	SRMR
Fit Value	2.766	0.941	0.935	0.924	0.951	0.053	0.062
Criteria	3	0.9	0.9	0.9	0.9	0.08	0.08
Fit result	Good	Good	Good	Good	Good	Good	Good

Table 7 Reliability and validity analysis results

Latent variables	Item	Item Loading	Z-Value	CR	AVE	α
Content coherence (CC)	CC1	0.776	10.223	0.8775	0.589	0.791
	CC2	0.717	9.892			
	CC3	0.767	10.181			
	CC4	0.761	10.047			
	CC5	0.814	13.157			
Interaction effectiveness (IE)	IE1	0.725	9.913	0.867	0.620	0.803
	IE2	0.814	13.156			
	IE3	0.828	13.655			
	IE4	0.779	10.321			
Platform functionality (PF)	PF1	0.812	13.114	0.910	0.671	0.842
	PF2	0.827	13.640			
	PF3	0.845	15.107			
	PF4	0.756	10.019			
	PF5	0.851	15.521			
Learning motivation (LM)	LM1	0.831	13.754	0.902	0.649	0.817
	LM2	0.725	9.914			
	LM3	0.852	15.529			
	LM4	0.827	13.641			
	LM5	0.787	10.422			
Learning satisfaction (LS)	LS1	0.751	10.008	0.897	0.635	0.809
	LS2	0.783	10.393			
	LS3	0.829	13.661			
	LS4	0.817	13.171			
	LS5	0.803	12.195			

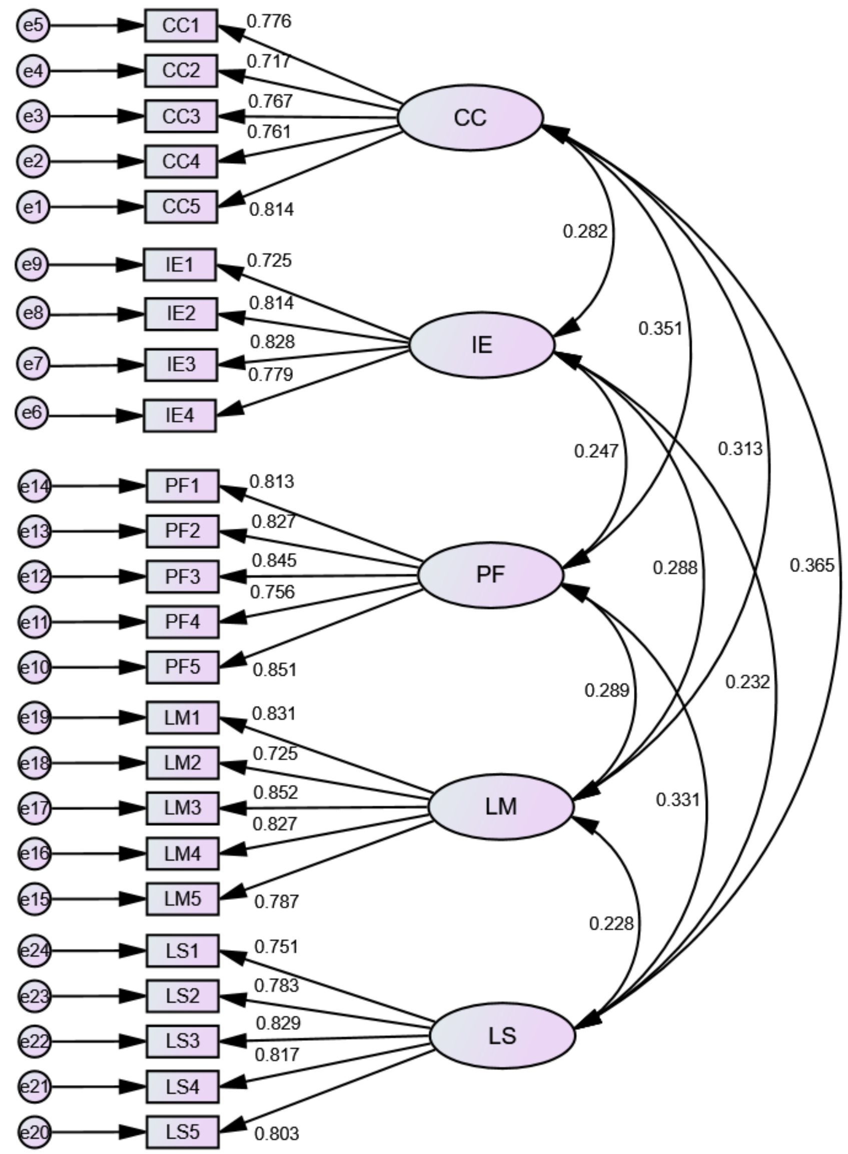

Fig. 3 CFA model (standardized output)

Discriminant validity (DV) referred to the degree to which a latent variable (i.e., a factor) was distinct from other latent variables. If the square root of AVE of a latent variable (i.e., DV) was greater than the correlation coefficient between that latent variable and other latent variables, it indicated good discriminative validity of the latent variable. As shown in Table 8, the DV values of each latent variable were higher than the correlation coefficient between that latent variable and other latent variables. This finding confirmed the discriminative validity of all five factors generated by the BLPS scale.

Table 8 Discriminant validity test results

Latent Variable	CC	IE	PF	LM	LS
CC	**0.767**	—	—	—	—
IE	0.462	**0.777**	—	—	—
PF	0.497	0.524	**0.819**	—	—
LM	0.501	0.546	0.556	**0.806**	—
LS	0.511	0.487	0.513	0.626	**0.797**

Note: The bold values in the diagonal represent DV value, the square root of AVE; and the values in the area below the diagonal are the Pearson correlations between latent variables.

Discussions

Developing BLPS via a standardized, structured, and scientific approach

The development process of the Blended Learning Perception Scale (BLPS) adhered to established norms (DeVellis & Thorpe, 2021). Initially, we curated items from existing scales designed for assessing blended or online learning programs, while carefully considering the unique characteristics of students in higher vocational schools. We further enriched the relevance and appropriateness of these items by incorporating expert opinions and soliciting feedback from students. Subsequently, the preliminary scale underwent a rigorous evaluation through both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) using data collected from two separate batches of 600 students, ensuring its validity and reliability.

The EFA process entailed the iterative extraction of major factors employing the principal component method with varimax rotation. Items with factor loadings below 0.4, double loading, or those deemed irrelevant or semantically incongruent with the corresponding factor were systematically removed. This analysis resulted in the confirmation of 24 items and the identification of five influential factors that shape student perceptions of blended learning programs: content coherence, interaction effectiveness, platform functionality, learning motivation, and learning satisfaction. Item-level scrutiny involving correlation analysis and independent sample t-tests affirmed the reliability and discriminative capability of all items, culminating in an overall Cronbach's alpha coefficient of 0.807.

The subsequent reliability and validity analysis of the CFA model yielded favorable outcomes. Each factor exhibited a Composite Reliability (CR) value exceeding 0.86, signifying robust internal consistency. Notably, these CR values exceeded their respective Cronbach's alpha coefficients, underscoring the appropriateness of item distribution and the representativeness of the selected factors. Furthermore, the Average Variance Extracted (AVE) values for each factor surpassed acceptable thresholds, affirming the convergence of each factor. Lastly, the fitness of the CFA model was rigorously assessed, yielding positive results.

Leveraging BLPS for evaluating blended learning and other instructional innovations in higher vocational education

Factor analysis of the 24 items revealed a comprehensive set of factors, comprising three extrinsic elements: content coherence, interaction effectiveness, and platform functionality, alongside two intrinsic factors: learning motivation and learning satisfaction. These factors collectively influence and govern student perceptions of blended learning programs within the context of higher vocational schools.

The three extrinsic factors align closely with the primary focal points of national vocational education reform. These encompass the transformation of teachers, teaching methods, and teaching materials as outlined by The State Council in 2019. This reform underscores the imperative for educators to proactively integrate emerging technologies, such as big data and artificial intelligence, into their pedagogical practices to enhance both teaching effectiveness and quality. Simultaneously, educators are encouraged to embrace and implement innovative instructional models and methodologies afforded by educational technologies. The reform initiative also emphasizes the establishment of standardized textbook norms for higher vocational education and the continuous development and dynamic updating of textbook content, as per The State Council's directives in 2021.

By addressing these three pivotal factors integral to the broader higher vocational education reform agenda, the developed BLPS scale not only serves as a valuable tool for assessing blended learning programs but also holds the potential for adaptation and utilization in measuring student perceptions across various innovative programs. This adaptability can contribute significantly to the advancement of high-quality vocational education, aligning with the evolving landscape of educational practices and technologies.

Improving future designs of blended learning programs based on factor-loading results

Factor loading is a standardized correlation coefficient that quantifies the relationship between a variable, represented by a scale item, and a potential factor. It serves as an indicator of the variable's significance within the context of the factor. The factor loading values for all 24 items of the BLPS, as presented in the CFA results detailed in Table 7, consistently met the accepted criteria, with 13 items reaching an excellent level (i.e., > 0.8).

Within the factor of content coherence, CC5 exhibited a notably high factor loading of 0.814, indicating that students perceive current blended learning programs in higher vocational schools as effectively distributing content for both online and offline learning. Furthermore, these programs are perceived as facilitative for acquiring both theoretical knowledge and practical skills (Suo, 2021). While items investigating the consistency of course content (CC1), learning objectives (CC3), and time arrangements (CC4) between online and offline sessions yielded generally positive responses, with factor loadings ranging from 0.76 to 0.78, there remains room for enhancing the connection between online and offline course content, as indicated by the relatively lower factor loading of CC2 (i.e., 0.717). This aspect aligns with concerns and discussions among researchers and practitioners in the field of blended learning, highlighting the need for continued improvement in this area.

Within the factor of interaction effectiveness, items IE2 and IE3, focusing on teacher supervision, feedback, and facilitation, exhibited relatively high factor loadings at 0.814 and 0.828, respectively. However, for IE1, the factor loading was comparatively lower (i.e., 0.725), signaling student expectations for more frequent interactions with both teachers and peers within the blended learning program. It's worth noting that frequent interactions may not necessarily translate into improved teaching and learning effectiveness (Tsou & Tsai, 2022). Decisions regarding the timing and frequency of diverse interaction forms should be context-specific, considering course content and classroom dynamics (Jiang et al., 2023). The final item, IE4, assessed student perceptions of the adequacy and effectiveness of assessments within the blended learning program and exhibited a factor loading of 0.779, underscoring student recognition of the importance of assessments in blended learning.

Within the extrinsic factor of platform functionality, most items displayed high factor loadings. Specifically, PF1, PF2, PF3, and PF5 achieved factor loadings of 0.812, 0.827, 0.845, and 0.851, respectively, all surpassing the 0.8 threshold. These findings affirm the comprehensive features and user-friendly nature of the online platform, which offers rich and inspiring resources, including educational videos conducive to learning (McDonald et al., 2021). Additionally, the platform provides functionalities that aptly accommodate practical needs. These positive outcomes are attributed to increased support for higher vocational education by national education authorities, with substantial funding allocated for the construction and enhancement of online course platforms. Collaboration with leading educational technology companies has further optimized these platforms, enhancing the user experience, especially with the advent of 5G technology, enabling swift and seamless campus wireless networks. Consequently, students now enjoy the flexibility of learning anytime, anywhere, access to diverse online resources, and interactive learning opportunities.

Nonetheless, within this factor, PF4 exhibited the lowest factor loading (i.e., 0.756), indicating the need for further refinement in the classification of online resources. This issue is intricately linked to the ambiguous definition and practice of group-based specialty instruction, commonly implemented in higher vocational education programs in China, which amalgamates related majors to facilitate resource sharing among teachers, courses, and other educational assets. Addressing this challenge will necessitate curriculum design and reform efforts.

Within the intrinsic factor of learning motivation, items LM1, LM3, and LM4 all garnered factor loadings exceeding 0.8, suggesting that students in higher vocational schools possess self-motivation and resilience, even when encountering obstacles (Alemayehu & Chen, 2023). For item LM5, the factor loading was 0.787, indicating that students recognize the importance of self-determined learning objectives, albeit necessitating further clarification (Kim, 2021).

Finally, for the last factor, learning satisfaction, LS3 achieved the highest factor loading of 0.829, indicating overall student satisfaction with the online learning platform, aligning with observations regarding platform functionality. Moreover, students in higher vocational schools express a preference for blended programs that seamlessly integrate online and offline learning spaces, as indicated by the factor loadings of items LS4 (i.e., 0.817) and LS5 (i.e., 0.813). However, student satisfaction with course content (LS1) and teaching arrangements (LS2) was less pronounced, with factor loadings of 0.751 and 0.783, respectively. These findings parallel student perceptions within the factor of content coherence, highlighting the need for enhancing the connection between online and offline course content and promoting interactive learning experiences.

Conclusion and limitation

This study has successfully developed and assessed a Blended Learning Perception Scale (BLPS) tailored for higher vocational students. The BLPS encompasses three extrinsic factors, including content coherence, interaction effectiveness, and platform functionality, as well as two intrinsic psychological factors, namely learning motivation and learning satisfaction. The scale's development followed a standardized, methodical, and scientific approach, demonstrating strong reliability and validity through both exploratory and confirmatory factor analyses (EFA and CFA).

In comparison to existing scales utilized in published research, the BLPS proves to be better suited for evaluating blended learning programs and innovative instructional approaches within the context of higher vocational education. The robust indicators for each factor (i.e., CR, AVE, and α) and item (i.e., factor loading and α after item deletion) have reached a commendable level. This indicates that blended learning, as an innovative instructional approach, enjoys widespread acceptance among higher vocational students. Consequently, higher vocational institutions should continue their coordinated efforts to promote, develop, implement, and optimize blended learning to better cater to the specific needs and characteristics of their courses and students.

Leveraging the insights from CFA results, which are based on data from a total of 300 students, this study has identified areas of success and opportunities for improvement in current blended learning programs within Chinese higher vocational schools. Among the five factors, student recognition of platform functionality stands out as the highest. This serves as compelling evidence of the effectiveness of policy support for the development of high-quality vocational education with a focus on technological design for blended learning. Conversely, student recognition of content coherence, particularly the alignment of online and offline content, ranks as the lowest. Given that coherent course design supports students in activating prior knowledge and integrating new information, there is a pressing need for the higher vocational education community to modernize and enhance established course content to achieve better consistency and cohesion within blended learning programs.

Enhancing student learning experiences and the overall effectiveness of blended learning programs in higher vocational schools is a comprehensive undertaking that involves multiple stakeholders, including policymakers, institutions, and enterprises. Employing the synergy theory as a guiding framework, which emphasizes the exchange of resources and information between internal subsystems and their external environment, can facilitate self-regulation and self-organization. A blended learning program encompasses numerous instructional processes and formats, demanding active involvement and facilitation from various parties, including policy advocates, platform developers, teacher trainers, financial backers, and technological infrastructure providers. Through frequent, multidirectional coordination and interaction, the system can achieve synergistic effects, optimizing resource allocation and superimposing efficiency. Ultimately, this results in the establishment of a dynamic, extensive resource and support system aimed at enhancing student experiences and achievements within blended learning programs in higher vocational schools.

However, this study is not without its limitations. First, the participants were drawn from a higher vocational school located in the Guangdong-Hong Kong-Macao Greater Bay Area, a highly developed region in China with advanced technological infrastructure and instructional capabilities for supporting blended learning program design and implementation. Thus, caution should be exercised when generalizing these findings to regions with varying levels of technological and instructional resources. Second, data collection occurred during the COVID-19 pandemic, during which participants primarily engaged in online learning from home or dormitories. This context may have influenced their perceptions and evaluations of blended learning. Further investigations conducted in the post-pandemic era are necessary to validate the scale's applicability. Lastly, the scale consists of a total of 24 items, which could be time-consuming and potentially prone to measurement errors due to boredom or carelessness. Future iterations of the scale should focus on simplification while maintaining its validity and reliability to ensure ease of use and timely feedback in evaluations of blended learning experiences.

Appendix 1：BLPS Questionnaire

Content coherence	5 SA	4 A	3 U	2 D	1 SD
1. The content of the online course is connected to the content of the offline course. There is no contradiction or conflict.					
2. The content between the online course and the offline course is well connected.					
3. The goals of the online course are the same as those of the offline course.					
4. Time allocation of the online and offline courses is reasonable.					
5. Content distribution of the online course and the offline course is appropriate and conducive to the learning of theoretical knowledge and practical skills.					
Interaction effectiveness	5 SA	4 A	3 U	2 D	1 SD
6. In the process of blended learning, teacher-student interaction and student-student interaction are frequent.					
7. The way Basic Accounting teaching is organized in blended teaching mode is very satisfactory.					
8. When students encounter difficulties in learning, teachers give timely help and support.					
9.The assessments of the course can evaluate student learning comprehensively.					
Platform functionality	5 SA	4 A	3 U	2 D	1 SD
10. The interaction function embedded in the platform meets the practical needs.					
11. I am satisfied with the functional design of the platform.					
12.The learning resources on the platform are rich and enlightening.					
13. The learning resources on the platform are clearly classified.					
14. The course videos on the platform are useful.					
Learning motivation	5 SA	4 A	3 U	2 D	1 SD
15. Even when study materials are dull and boring, I keep working until I finish.					
16. When the task is difficult, I either give up or only complete the easy part.					
17. When I encounter difficulties in a course, I can motivate myself to complete the work.					
18. Even if I do not like an assignment, I can motivate myself to work on it.					
19. I set goals for the grades I want to get in a course.					
Learning satisfaction	5 SA	4 A	3 U	2 D	1 SD
20. I am very satisfied with the content of the online and offline courses.					
21. I am very happy with the way teaching is organized in the blended learning program.					
22. I am very satisfied with the platform for online learning.					
23. I really like the instruction model that combines online and offline teaching.					
24. I think the combination of online and offline teaching is more effective than purely teaching online or offline.					

Abbreviations

BLPS: Blended Learning Perception Scale; CC: Content Coherence; IE: Interaction Effectiveness; PF: Platform Functionality; LM: Learning Motivation; LS: Learning Satisfaction; EFA: Exploratory Factor Analysis; CFA: Confirmatory Factor Analysis; AVE: Average Variance Explained; DV: Discriminant Validity.

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Authors' contributions

The authors are responsible for the whole manuscript. The authors read and approved the final manuscript.

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Availability of data and materials

Data sharing is not applicable to this article.

Declarations

Competing interests

The authors declare that they have no competing interests.

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