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Development and Validation of the Blended Learning Effectiveness and Challenges Scale (BLECS) in the Indian Educational Context

Saurabh Kalra[1]*, Nandini Srivastava[1], Vandana Gambhir[2]

[1]Department of Management, Manav Rachna International Institute of Research & Studies (MRIIRS), Haryana, India, [2]Department of Psychology, University of Delhi, India. *Corresponding Author's Email: kalra234@gmail.com

Abstract

In higher education worldwide, blended learning has become an ordinary component of the student experience. However, few reliable tools are available to evaluate students' perceptions of learning environments in blended learning settings despite these perceptions being a crucial component of the learning process. This paper detailed the preliminary creation and validation of the Blended Learning Effectiveness and Challenges Scale (BLECS) perceptions in the Indian Educational Context. The analyses, involving a sample of 500 Indian students currently enrolled in government or private universities of Delhi NCR, belonging to different fields using purposive sampling, consistently supported the trifactor model. Separately, there were three specific factors: Blended Learning Effectiveness (BLE), Technology Integration and Educational Outcomes (TIEO) and Blended Learning Challenges (BLC), each having its own separate set of items. The study confirmed that the BLECS demonstrated a consistent factor structure, factor loadings, and intercepts. This suggests that the BLECS could be valuable in exploring students' perceptions of blended learning environments across various academic disciplines exploring students' perceptions of blended learning environments across various academic disciplines.

Keywords: Blended Learning, Blended Learning Effectiveness, Exploratory Factor Analysis, Technology-Enhanced Learning.

Introduction

The education landscape has undergone significant transformations in recent years, with blended learning emerging as a prominent and innovative approach mainly driven by technological advancements and the increasing demand for flexible learning environments. This pedagogical approach offers a dynamic and adaptable learning environment by combining traditional in-person training with online elements (1). This seeks to establish a more effective, individualized, and interesting learning environment. It gives students authority over important facets of their education, including how they go through the curriculum, when and where they interact with the materials, and how quickly they advance. Because of this flexibility, teachers may tailor the combination of online and in-person instruction to meet the needs of their students, particular learning objectives, and institutional resources. Integrating digital tools like video lectures, interactive simulations, and online forums expands the scope of traditional education, allowing educators to engage students in more dynamic and interactive ways. This blend of face-to-face and virtual learning environments enhances independent exploration and fosters a deeper understanding of the subject, creating a more responsive and adaptive learning experience. Research evidence claims that the thoughtful blending of conventional and digital approaches is at the core of blended learning (2). The expansion of education beyond the classroom is made possible by the significant role played by technology, while connections are fostered, prompt feedback is provided, and teamwork is promoted through face-to-face contact. Both methods are balanced in blended learning, and their advantages are leveraged to ensure that a thorough and rewarding educational experience is delivered (3). Additionally, by maximizing resources and getting around physical classroom constraints, this method has useful benefits. In today's diverse

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educational landscape, where students have varied backgrounds and needs, blended learning proves particularly effective in catering to their distinct preferences and supporting their learning journeys.

Blended Learning Relevance and Current Trends

The hybrid blended learning model offers several advantages over online or in-person instruction. A growing body of research has demonstrated blended learning's potential to enhance educational outcomes by providing students with a more personalized and flexible learning experience (4, 5). One key benefit of blended learning is its ability to accommodate diverse learning styles and paces. It has been found that blended learning allows students to engage with electronic materials at their convenience, leading to improved learning performance compared to traditional methods (5). This flexibility is particularly important in higher education, where students often manage multiple responsibilities. Higher exam scores and overall performance have also been observed among students in blended learning settings compared to traditional ones (4). Blended learning fosters increased interaction and collaboration by integrating online platforms, which facilitate timely communication and feedback—essential components of effective learning. Research has shown that online components of blended learning enhance students' curiosity and motivation, leading to improved communication skills (6). Furthermore, it has been emphasized that the quality and quantity of interactions in blended learning environments significantly influence academic success (7).

Research further indicates that blended learning cultivates critical thinking, problem-solving, and self-directed learning (SDL) competencies. Blended learning has been proposed to foster critical thinking, questioning, and collaboration among students—all of which are key skills in today's knowledge-driven economy (8). Problem-based blended learning has also enhanced learning outcomes and creative thinking (9). This emphasis on higher-order thinking abilities is essential for equipping kids to face obstacles in the actual world. By fostering a dynamic, adaptable learning environment, blended learning enhances student motivation, engagement, and academic advantages (10). Because of the flexibility blended learning offers, learning becomes more dynamic and responsive to shifting needs.

Self-directed learning (SDL), a crucial skill in contemporary education, is being acknowledged increasingly as being fostered via blended learning. The ability of students to take charge of their education, including organizing, carrying out, and assessing their educational experiences, is known as self-directed learning (SDL) (11). Research indicates that blended learning environments significantly enhance self-directed learning capabilities. For instance, a study demonstrated that nursing students who engaged in a blended self-directed learning approach showed improved readiness for self-directed learning, suggesting that such educational interventions can effectively prepare students for lifelong learning (12). It has been observed that midshipmen in a blended learning setting exhibit high levels of self-directed learning readiness, indicating that an active blended environment fosters autonomy and initiative among learners who are better equipped to manage their educational journeys (13). Another study emphasizes that when students can choose their learning content and control their pace, they experience higher satisfaction and engagement (14). This autonomy enhances motivation and aligns with self-determination theory, which posits that individuals are more likely to thrive in environments that support their intrinsic motivation and self-directed efforts. Such environments encourage students to take ownership of their learning, leading to deeper engagement and better academic outcomes. The benefits of blending formal and informal learning approaches extend beyond the educational context; many organizations are now focusing on self-directed learning to foster employee growth, satisfaction, and organizational development. For example, a recent study found a significant association between self-directed learning and job satisfaction, highlighting the value of blended learning beyond academic settings (15).

Additionally, blended learning promotes the development of self-regulated learning skills essential for effective self-directed learning. A study found that blended learning settings can enhance self-regulation in learning behaviours, thereby improving student's ability to control their learning processes and achieve better academic results (16). This is crucial in preparing students for the demands of both educational and professional environments, where self-regulation and initiative are highly valued. Furthermore, the role of instructors in blended learning environments cannot be overlooked. Educators who recognize and support students' self-directed learning capabilities can optimize learning opportunities and create meaningful educational experiences. It has been noted that instructors play a pivotal role in facilitating self-directed learning by providing guidance and resources that empower students to take charge of their learning (17).

Several current trends, educational shifts, and technological advancements underscore the relevance of blended learning in today's educational landscape. One significant trend is the increasing emphasis on student-centered learning approaches. Blended learning aligns well with this shift, allowing for greater flexibility and personalization in the learning experience. It has been highlighted that the evolution of the educational technology industry in countries like China and the United States has led to innovative blended learning solutions that cater to diverse learner needs (18).

Technological advancements also play a crucial role in making blended learning particularly relevant today. Online and in-person learning may now be effortlessly combined because to the rapid progress of information and communication technology (ICT), which has completely changed traditional teaching approaches. According to research, blended learning—often referred to as the "new normal" in course delivery—has gained widespread acceptance in higher education (19). According to studies on the advantages and difficulties of online education at this time, the COVID-19 epidemic has sped up this change by requiring a quick switch to online and mixed learning approaches (20).

Moreover, the rise of Massive Open Online Courses (MOOCs) has significantly influenced the blended learning landscape. A study indicates that integrating MOOCs into traditional courses can enhance learning outcomes and give students the flexibility to learn at their own pace (21). This model supports individual learning needs and aligns with the broader trend of lifelong learning as students increasingly seek opportunities to up skill and reskill in a rapidly changing job market. The pedagogical shift towards active learning strategies is another critical factor driving the relevance of blended learning. The flipped classroom model, which combines pre-class online activities with in-class discussions, has promoted self-directed learning and improved student performance (22). This approach encourages students to take responsibility for their learning, fostering essential skills such as critical thinking and problem-solving. It has been noted that combining online and face-to-face learning supports diverse learning preferences and creates opportunities for meaningful interactions among students and instructors (22). This aspect is crucial in higher education, where collaboration and networking are essential for academic and professional success.

In summary, blended learning—which combines in-person and virtual instruction—has become more important in education, particularly during the COVID-19 epidemic (23). It has been shown to improve learning results, especially in health education, where it frequently outperforms conventional techniques (24). Nonetheless, issues continue to exist, such as students' struggles with technology and self-control and instructors' inexperience with teaching resources (25). Other challenges for educational institutions are effective teacher preparation and sufficient technology resources (25). Research on blended learning is still scarce in poor countries while being widely explored in higher education in wealthy nations (18). Notwithstanding these problems, this strategy has much potential since it blends the benefits of in-person and virtual learning (23). Future research should tackle these issues and look at different blended learning design methods (24).

Conceptual Framework behind Scale Development

The foundation of the study on scale development for blended learning is anchored in three fundamental theories: Constructivist Learning Theory, Technology-Enhanced Learning, and Social Cognitive Theory. Each theory provides a framework for understanding how blended learning can be effectively implemented and measured.

Constructivist Learning Theory suggests that learners actively build their understanding and knowledge of the world through personal experiences and reflection (26, 27). In blended learning environments, this theory emphasizes the importance of active engagement and collaboration among students. For instance, a study highlights that blended learning enhances English reading skills by allowing students to engage with content through various technological tools, which supports their active learning process (28). This aligns with the constructivist view that learning is most effective when students interact meaningfully with materials. Moreover, another research indicates that blended learning environments foster self-regulated and self-directed learning skills crucial for constructivist learning (29). The study suggests that blended learning offers numerous advantages but also challenges instructors in designing materials that encourage active participation. This reinforces that constructivist principles must be carefully integrated into blended learning frameworks to maximize effectiveness. It has been noted that while many blended learning tools exist, assessing their quality is difficult (30). The need for technology to enhance meaningful learning is emphasized, as learning is most effective when students can interact with content in a meaningful way, aligning with constructivist principles. Similarly, it has been found that blended learning improved students' perceptions without affecting traditional performance, supporting the idea that it enhances engagement and understanding of complex concepts (31).

Technology-enhanced learning (TEL) integrates technology to facilitate and improve learning experiences. The COVID-19 pandemic has accelerated the adoption of blended learning, making TEL particularly relevant (32). One study asserts that blended learning became paramount during the pandemic, leading to a significant shift in educational practices worldwide (33). This shift underscores the necessity of leveraging technology to create flexible and adaptive learning environments. Another research discusses the evolving definitions of blended learning and emphasizes technology's importance in creating effective learning experiences (19). This is further supported by a study that assesses perceptions of blended learning among anatomists, highlighting the role of faculty development in effectively utilizing technology within blended learning contexts (34). A systematic review has found that blended learning is more effective when instructional technology supports cognition, such as visualizing abstract concepts, rather than merely facilitating communication (35). This underscores the importance of using technology to enhance cognitive processes, a core tenet of TEL. Additionally, it has been discussed how mobile learning and mobile devices can create flexible learning environments that support student communication and interaction, further illustrating the importance of TEL in blended learning contexts (36).

Social Cognitive Theory (SCT) emphasizes the role of observational learning, imitation, and social interactions in learning (37). This theory is particularly relevant in blended learning environments, where students can learn from peers and instructors. Research indicates that understanding student perceptions of blended learning is crucial for enhancing motivation and interest, which are key components of SCT (38). By fostering a collaborative learning environment, blended learning can improve students' social interactions and support their learning processes. Additionally, a systematic review highlights the importance of social interactions in blended learning environments, suggesting that effective collaboration among students can lead to improved learning outcomes (18). This aligns with the principles of SCT, which posits that social influences play a significant role in shaping learning behaviours and attitudes. It has been found that contextual factors, self-efficacy, and motivation significantly influence learners' adaptability to blended learning, with these findings aligning with SCT and suggesting that learners' interactions with their environment and self-efficacy are critical for successful learning experiences (39). This supports the idea that social interactions in blended learning can enhance motivation and engagement. Furthermore, student perceptions of blended and online learning courses have been examined, revealing that collaborative dynamics and social interactions significantly influence learning outcomes (40).

Considering the above-reviewed conceptualizations and research, blended learning models have proliferated at higher education institutions. However, one crucial issue is the need for valid and reliable scales to measure blended learning approaches and their effectiveness.

Developing standardized scales is vital for researchers to assess blended learning implementations quantitatively, compare results across studies, and advance our understanding of what blended learning models work best and in what contexts.

While some initial attempts have been made to design scales focused on blended learning (41, 42), the field would benefit from additional scale development research and validation studies. In particular, existing blended learning scales tend to focus more narrowly on specific blended learning components like technology acceptance or student satisfaction without comprehensively capturing the pedagogy of the whole blended learning experience from a student's perspective. A broader, multi-dimensional scale is needed to gauge critical challenges in implementing the blended model. Thus, this study seeks to address the identified gap by developing and validating a new scale to assess the effectiveness and challenges of blended learning implementation.

Methodology

This study, designed to create a scale for assessing the effectiveness and challenges of blended learning within the Indian education context, follows a basic quantitative research approach. The research was carried out in a stepwise process. The first step involved generating the item pool, while the second step focused on conducting an exploratory factor analysis (EFA). EFA was used on the items produced empirically to develop the scale's theoretical foundation.

Participants

A sample of 500 Indian students was taken from both government and private universities and institutions of Delhi NCR. Data were gathered through purposive sampling. The sample composition comprised 52.7% males (n = 263) and 47.3% females (n = 236); there was less of a gender gap. The educational background of students varies from bachelor's (26.1%, n = 130), master's (23%, n =115) to PhDs (24.2%, n =121), and some belonging to other categories (26.7%, n =133) of different courses and semesters as well. Table 1 contains other demographic and contextual details.

Table 1: Demographic and Contextual Characteristics of the Sample (n = 500)

Characteristic		**Number**	**%**
Institution Type	Government University/Institution	172	34.5
	Private University/Institution	166	33.3
	Others	161	32.3
Field of Study	Humanities and Social Sciences	111	22.2
	STEM (Science, technology, Engineering and Mathematics)	132	26.5
	Commerce, Business, Law and Management	125	25.1
	Others	131	26.3
Previous Experience with Blended Learning	Yes	235	47.1
	No	264	52.9
Frequency of Internet Access	Daily	87	17.4
	Several Times Week	115	23.0
	Once A Week	91	18.2
	Rarely	103	20.6

	Never	103	20.6
Residential Status	On-Campus	112	22.4
	Off-Campus	155	31.1
	Commuter	99	19.8
	Others	133	26.7
Access to Personal Computer or Laptop	Yes	256	51.3
	No	243	48.7
Access to High-Speed Internet Connection	Yes	245	49.1
	No	254	50.9
Familiarity with Blended Learning	Very Familiar	169	33.9
	Somewhat Familiar	161	32.3
	Not At All Familiar	169	33.9
Preferred Learning Environment	Face To Face Classroom	130	26.1
	Blended Learning	129	25.9
	Online Environment (Only)	116	23.2
	Others	124	24.8

Participants must meet specific eligibility criteria to ensure the research targets the intended population. Qualified individuals must be at least undergraduate students or higher education holders actively pursuing degrees in Humanities and Social Sciences, STEM (Science, Technology, Engineering, and Mathematics), or Commerce, Business, Law, and Management. Additionally, they must have completed at least one year of undergraduate studies, equivalent to two semesters. Participants should also be enrolled in educational institutions within the Delhi NCR region that implement blended learning methods. Certain factors will disqualify potential participants. Only currently enrolled students are eligible, and those who have not completed their first year (two semesters) of undergraduate education will not be considered. Students from institutions outside the Delhi NCR region or those that do not use blended learning methods are also excluded from the study.

Development of the Scale

This scale was developed to evaluate individuals' effectiveness and challenges in achieving blended learning. Firstly, an item pool was created based on theories of constructivist learning, social cognition, and the role of technology in enhancing education. Items generation was mainly focused on blended learning flexibility, participation, technology access, learning outcomes, infrastructures, and time management challenges. Experts in the field were consulted to review the items for relevance before the scale was administered. Based on their feedback, 24 items were selected. These items were then tested on a sample of 500 participants. Each item was rated on a 5-point Likert scale, ranging from 1 “Strongly Disagree” to 5 “Strongly Agree,” with 3 representing “Neither Agree nor Disagree.”

Procedure

The authors approached the study participants both in person and through online platforms, using Google Forms to collect data. Informed consent was obtained from each participant. Participants were informed to select the most appropriate responses, and the researchers recorded the responses. To maintain anonymity and confidentiality, no participant names were recorded. Before conducting factor analysis, the data was checked for missing values and then subjected to descriptive statistical analysis. Using the Kaiser-Meyer-Olkin (KMO) test, Bartlett's test of sphericity, and Kaiser's requirement for eigenvalues greater than 1, the sufficiency of the data for EFA was verified. The factor extraction and rotation techniques used were principal component analysis and varimax rotation, respectively.

The development of the Blended Learning Effectiveness and Challenges Scale (BLECS) was grounded in three key theoretical frameworks: Constructivist Learning Theory, Technology-Enhanced Learning (TEL), and Social Cognitive Theory (SCT). Each scale item was meticulously designed to reflect these theoretical underpinnings, ensuring a robust conceptual foundation. For instance, items under the Blended Learning Effectiveness (BLE) factor, such as BLE-1 ("Blended learning helped me understand complex concepts more effectively to enhance my comprehension"), are rooted in Constructivist Theory, emphasizing the importance of interactive and engaging learning environments. Similarly, items under the Technology Integration and Educational Outcomes (TIEO) factor, such as TIEO-3 ("Technology-enhanced learning environments better prepare students for careers in the rapidly evolving technology industry"), align with the principles of TEL, highlighting the role of digital tools in enhancing academic and professional readiness. Finally, items under the Blended Learning Challenges (BLC) factor, such as BLC-4 ("Resistance to change among teachers and students with reluctance to adopt new teaching methodologies, including blended learning, hinder implementation efforts"), are informed by SCT, which underscores the significance of social adaptation and observational learning in overcoming barriers to educational innovation. This alignment between scale items and theoretical frameworks strengthens the scale's validity and ensures its relevance to the blended learning context.

Results

As presented in Table 2, means and standard deviations were computed for all 24 items on the BLEC Scale to gain an initial understanding of response patterns. The mean for technology integration and educational outcomes (M = 1.95, SD = 0.78) was low. In contrast, the means for blended learning effectiveness (M = 2.58, SD = 1.13) and blended learning challenges (M = 2.42, SD = 1.0) fell within the medium range.

Table 2: Descriptive Statistics of the items of BLECS (n = 500)

Code	Items of BLECS	Mean	SD
BLE-1	Blended learning helped me understand complex concepts more effectively to enhance my comprehension.	3.06	1.14
BLE-2	The combination of online resources and in-person instruction improved my overall learning experience.	2.42	1.10
BLE-3	Blended learning allowed me to learn at my own pace and review materials as needed to enhance my comprehension.	2.75	1.23
BLE-4	Interactive online activities and discussions deepened my understanding of the subject matter under blended learning.	2.70	1.18
BLE-5	The flexibility of blended learning approaches accommodated different learning styles and preferences to enhance my comprehension.	2.71	1.21
BLE-6	With blended learning, technical issues with online platforms sometimes hindered my learning experience.	1.99	1.05
BLE-7	Maintaining motivation and self-discipline in online components was challenging.	2.66	1.10
BLE-8	Under Blended learning process, limited interaction with instructors and peers in online components reduced my engagement.	2.22	0.99

BLE-9	Assessments and feedback in blended learning environments were not always clear or timely.	2.26	1.11
BLE-10	With Blended Learning the integration of online and in-person components lacked coherence and consistency.	3.05	1.17
TIEO-1	Technology integration in education improves student engagement and participation in coursework.	1.82	0.85
TIEO-2	Technology-enhanced learning activities promote deeper understanding of complex concepts.	1.88	0.59
TIEO-3	Technology-enhanced learning environments better prepare students for careers in the rapidly evolving technology industry.	1.52	0.81
TIEO-4	The integration of technology in education improves retention rates and reduces dropout rates among students.	1.98	0.80
TIEO-5	Technology integration supports the development of transferable skills such as problem-solving and communication in students.	1.83	0.37
TIEO-6	Students demonstrate greater mastery of course content when technology is integrated into their learning experiences.	1.62	0.88
TIEO-7	Technology integration plays a crucial role in advancing the quality and effectiveness of education.	2.37	0.88
TIEO-8	The integration of technology in education enhances the overall academic performance of students.	2.60	1.04
BLC-1	There is a lack of adequate technological infrastructure (e.g., reliable internet connection, access to devices) that hinders the implementation of blended learning.	2.24	1.01
BLC-2	Managing technical issues and troubleshooting problems related to technology usage during blended learning sessions is challenging for both instructors and students.	2.66	1.03
BLC-3	Budget constraints and resource limitations prevent institutions from investing in the necessary infrastructure and support systems for implementing blended learning practices effectively.	2.42	1.07
BLC-4	Resistance to change among teachers and students with reluctance to adopt new teaching methodologies, including blended learning, hinder implementation efforts.	2.49	0.99
BLC-5	Insufficient training and professional development opportunities for teachers and students on how to effectively integrate technology into their teaching practices pose a barrier to implementing blended learning.	2.28	0.88
BLC-6	Limited access to high-quality digital learning materials and resources impedes the successful implementation of blended learning practices.	2.42	1.02

Note:BLECS = Blended Learning Effectiveness and Challenges Scale; BLE = Blended Learning Effectiveness; TIEO = Technology Integration and Educational Outcomes; BLC = Blended Learning Challenges

Before conducting EFA, the necessary assumptions were tested, following the recommendations in the literature (43). The suitability of the data for factor analysis was evaluated through Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. These tests are essential to determine whether the data is appropriate for EFA. In this study, the KMO value was 0.845, above the acceptable threshold of 0.8, indicating that the sample was adequate for factor analysis (44). Bartlett's Test of Sphericity yielded $\chi 2$ (276) = 3640.93, which was significant at $p < 0.000$, confirming that the assumption of multivariate normality was met (43, 44).

Lastly, the eigenvalue of 5.45 was obtained for the first factor, 3.22 for the second factor and 1.55 for the third factor, respectively. In all, 22.71% of the variance was explained by Factor 1, whereas variance explained by second and third were 13.43% and 6.47%, respectively. Table 3 shows eigenvalues and percentages of variance explained by each factor. Furthermore, as shown in Figure 1 scree plot was generated to assess the number of factors to retain (45). The plot revealed a distinct elbow at the third factor, indicating that three factors explained a substantial amount of variance. Eigenvalues for the first three factors were all above 1.0 (46), further supporting this decision. Based on these findings, a three-factor solution was chosen for further analysis.

Table 3: Eigenvalues and Percentage of Variance explained by three factors in the 24-Item BLECS, derived from Principal Component Analysis (N = 500)

Factor	Eigenvalues	Percentage of Variance Explained	Cumulative Percentages
1 (BLE)	5.45	22.71	22.7
2 (TIEO)	3.22	13.43	36.14
3 (BLC)	1.55	6.47	42.62

Note: BLECS = Blended Learning Effectiveness and Challenges Scale; BLE = Blended Learning Effectiveness; TIEO = Technology Integration and Educational Outcomes; BLC = Blended Learning Challenges

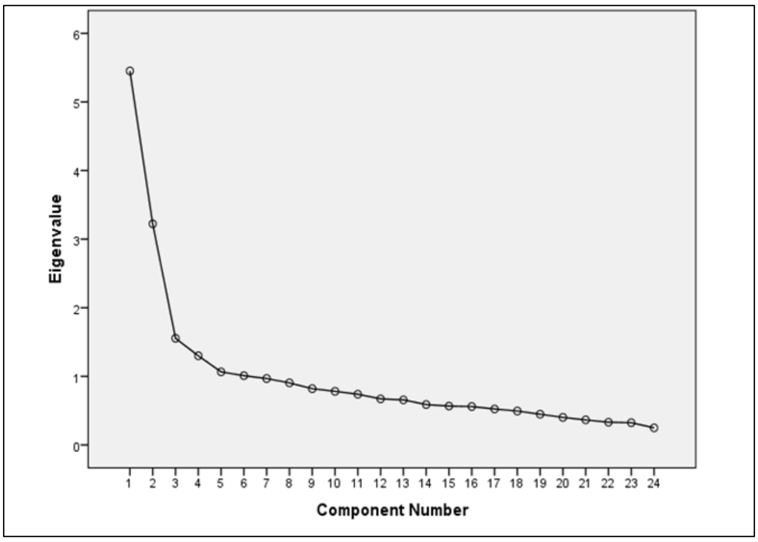

Figure 1: Scree Plot Showing Extraction of Factors of Blended Learning Effectiveness and Challenges Scale for Learners (BLECS)

The study followed recommendations from experts regarding factor extraction and rotation methods (47, 48). Principal component analysis (PCA) was used to identify the ideal number of factors. The rotated component matrix was examined, with values above 0.3 indicating a strong correlation between a variable and underlying factor (49). Following precedent, 0.30 was set as the threshold for retaining an item within a given factor.

The factor loadings and communalities (h^2) of the 24 items of BLECS are presented in Table 4. The three-factor solution accounted for 42.62% of the total variance across all dimensions. After applying varimax rotation, the first factor, which explained 18.68% of the variance, was the most significant, followed by the second and third factors, accounting for 17.14% and 6.8% of the variance, respectively. Items BLE-1 to BLE-10 loaded exclusively on Factor 1 with loadings between 0.74 and 0.48, and were retained due to their loadings and theoretical alignment. Similarly, items TIEO-1 to TIEO-8 loaded on Factor 2 with loadings ranging from 0.75 to 0.39 and were also retained for the same reasons. Lastly, items BLC-1 to BLC-6 loaded on Factor 3 with loadings between 0.79 and 0.50, and were likewise retained. Thus, a three-factor scale was finalized, considering factor loadings, theoretical relevance, and item content.

Table 4: Communalities and Factor loadings (EFA) of BLECS (Three - Factor Solution)

Code	Communalities (h^2)	Factor 1	Factor 2	Factor 3
BLE-1	.384	.482		
BLE-2	.343	.577		
BLE-3	.518	.711		
BLE-4	.380	.606		
BLE-5	.323	.567		
BLE-6	.371	.602		
BLE-7	.495	.686		
BLE-8	.485	.685		
BLE-9	.404	.628		
BLE-10	.492	.686		
TIEO-1	.334		.390	
TIEO-2	.331		.435	
TIEO-3	.372		.520	
TIEO-4	.480		.689	
TIEO-5	.354		.470	
TIEO-6	.342		.440	
TIEO-7	.531		.687	
TIEO-8	.577		.755	
BLC-1	.633			.790
BLC-2	.629			.784
BLC-3	.608			.776
BLC-4	.543			.720
BLC-5	.535			.718
BLC-6	.368			.503

Note: BLECS = Blended Learning Effectiveness and Challenges Scale; BLE = Blended Learning Effectiveness; TIEO = Technology Integration and Educational Outcomes; BLC = Blended Learning Challenges

All items exhibited communalities of 0.30 or higher, ranging from 0.323 to 0.633, indicating a good representation of the shared variance. The rotated component matrix, using varimax rotation, revealed a distinct three-factor structure with no cross-loadings, confirming the validity of this blended learning model for the student population. The factors were analysed based on the content of the items and their underlying themes. The first factor, consisting of ten items related to the effectiveness of blended learning, was labelled "Blended Learning Effectiveness." The second factor, titled "Technology Integration and Educational Outcomes," included eight items measuring the role of technology in education and its impact on learners. The third factor, comprising six items, focused on the challenges learners face in blended learning and was labelled "Blended Learning Challenges."

Discussion

The current study aimed to develop and validate a scale to assess the effectiveness and challenges of blended learning in the Indian education context. An initial item pool was generated based on literature review, some theories (constructivist learning theory, technology-enhanced learning, and social cognitive theory) and expert feedback. Subsequently, exploratory factor analysis was conducted on the responses from a sample of 500 Indian university students.

The descriptive statistics provided initial insights into students' perceptions. The lower mean for

"Technology Integration and Educational Outcomes" suggests that participants generally perceived the integration of technology in blended learning and its impact on educational outcomes as less effective or less favourable. This could indicate challenges or limitations in the use of technology within the educational environment, such as insufficient access to resources, inadequate training, or technology not being fully utilized to enhance learning outcomes. It may also reflect skepticism about the benefits of technology in improving educational results among the participants. Additionally, while the integration of technology is frequently discussed, there is often insufficient attention given to the challenges instructors face in implementing blended learning effectively. It has been highlighted that instructors must develop materials and methods that actively engage learners, which can be a significant hurdle in practice, but there is scope for improvement in effective technology integration to maximize learning benefits (29). The medium means for 'Blended Learning Effectiveness' and 'Blended Learning Challenges' indicate that while students recognize blended learning's benefits, certain challenges persist as well.

The EFA results establish the multidimensionality of the BLECS construct. The Kaiser-Meyer-Olkin and Bartlett's Test values supported the sampling adequacy and suitability of EFA. Three distinct factors with eigenvalues above 1 were extracted based on scree plot evaluation, together explaining 42.62% of the total variance. The EFA results showed clear factor loadings. Items BLE-1 to BLE-10 (10 items) loaded exclusively on Factor 1, representing 'Blended Learning Effectiveness,' with loadings from 0.74 to 0.48. Items TIEO-1 to TIEO-8 (8 items) loaded on Factor 2, representing 'Technology Integration and Educational Outcomes,' with loadings from 0.75 to 0.39. Items BLC-1 to BLC-6 (6 items) loaded on Factor 3, representing 'Blended Learning Challenges,' with loadings from 0.79 to 0.50. All items demonstrated a simple structure, loading significantly on their intended factors. Factor 1 comprised items related to blended learning's instructional organization, flexibility, interaction and participation - key determinants of an effective blended model. Factor 2 focused on technology integration aspects like access, skills and its impact on learning processes and outcomes. Factor 3 captured infrastructure, technical and time management challenges that impede optimal blended learning experiences. The items exhibited moderate to high communality values, demonstrating adequate common variance. Overall, the factor structure and loadings provided empirical evidence for conceptualizing blended learning effectiveness, technology integration outcomes and challenges as independent yet interrelated dimensions.

The findings offer valid evidence for using the BLECS to assess these three factors of the blended learning model in Indian higher education. Institutions can use the scale to evaluate blended programs and identify improvement areas from student perspectives.

BLECS stands out from existing scales by addressing both the effectiveness and challenges of blended learning, unlike the Blended Learning Acceptance Scale (BLAS), which focuses solely on technology acceptance. It also goes beyond the Blended Learning Effectiveness Tool by including barriers learners and educators face. Designed for the Indian educational context, BLECS captures cultural nuances often overlooked by other scales with a generic international focus. Its validated three-factor structure ensures robustness, making it a comprehensive tool for blended learning research. This unique combination of depth and specificity fills critical gaps in the field.

Insights into Technology Integration Findings

Lower perceptions of technology integration in blended learning may result from inadequate infrastructure, limited digital literacy, and insufficient institutional support. Educators often lack training to align technology with curriculum goals, reducing effectiveness. Addressing these barriers requires professional development for educators and digital literacy programs for students. Investments in internet access and modern devices are also critical for equitable learning opportunities. These efforts can bridge the gap between technological advancements and their effective use in education.

Practical Implications

The development of the BLECS has meaningful implications for various stakeholders in Indian higher education. The scale offers educators a practical way to understand how students perceive blended learning, helping them pinpoint what works and what doesn't. This allows teachers to fine-tune their approach, such as finding the right balance between online and face-to-face components to make learning more effective and engaging. Policymakers can also benefit from BLECS as it highlights trends and challenges across institutions, giving them a clear picture of where improvements are needed. For example, if data shows that many students struggle due to poor internet access or a lack of training, policymakers can prioritize investments in these areas. This might include funding for better digital infrastructure or workshops to help educators integrate technology into their teaching. Students, too, play an important role in this process. BLECS allows them to share their experiences, ensuring their voices are heard when shaping future learning methods. For instance, as Table 1 reveals, a lack of reliable technology is a major barrier—something institutions can address by improving access to devices and high-speed internet. Ultimately, BLECS offers practical insights that can help everyone—teachers, students, and policymakers—work together to make blended learning more effective, accessible, and rewarding.

Limitations

The present study provides a preliminary validation of the BLECS for assessing blended learning in India. However, the results should be interpreted considering its limitations. Firstly, the sample was recruited from universities in a single geographic region (Delhi NCR), so the generalizability of findings to other parts of India may be limited, which future studies should address by drawing a nationally representative sample. Furthermore, the sample size, while adequate for EFA, was insufficient for generalizing findings across India's diverse population and provinces. Larger samples drawn from multiple cities and regions are needed to establish the BLECS's validity across varied contexts. Additional psychometric analyses like test-retest reliability and different forms of validity (e.g. convergent, discriminant validity) were not assessed, limiting the scale validation. Further analyses are needed, specifically CFA to confirm the factor structure.

The explanatory power of the three-factor model was modest at 42.62%, which indicates the need to explore additional relevant factors through continued scale refinement. A higher percentage of variance explained would strengthen the scale's validity. Cross-cultural validation studies administering the scale across diverse cultural settings would also demonstrate its potential to explore blended learning effectiveness in a multicultural framework. Comparative analyses could provide valuable directions for future research as blended learning evolves.

Moreover, the reliance on self-reported data introduces potential biases, such as social desirability or subjective interpretation of items, which may influence the accuracy of responses. The use of a convenience sample further limits the representativeness of the findings, highlighting the need for more rigorous sampling methods in future studies. Addressing these issues will enhance the robustness and applicability of BLECS across diverse educational settings.

Conclusion

The primary objective of this study was to enhance existing knowledge by developing a scale to evaluate the effectiveness and challenges of blended learning methods, specifically aimed at improving the academic performance of graduate students. The findings from this research provide valuable insights into the key factors influencing blended learning, including the impact of technology integration, and highlight areas where improvements are needed. This knowledge will play a crucial role in guiding the development and implementation of blended learning approaches tailored to the unique needs of graduate students, ultimately leading to better educational outcomes and a more enriching learning experience.

Future research should examine the relationship between BLECS scores and key educational outcomes to further establish the scale's predictive validity. For example, correlational studies could assess how specific BLECS factors, such as Blended Learning Effectiveness (BLE) or Technology Integration and Educational Outcomes (TIEO), are associated with objective metrics like Grade Point Average (GPA), student retention rates, or levels of academic engagement. Applying BLECS in diverse educational and cultural contexts would provide valuable insights into its cross-cultural reliability and validity. Administering the scale across different geographic regions and institutional types, both within and outside the Indian context, could help identify cultural nuances in blended learning perceptions. Such efforts would enhance the generalizability of BLECS and contribute to the refinement of culturally responsive blended learning frameworks and pedagogical strategies.

Cultural attitudes toward technology and hierarchical systems in Indian education can influence responses to BLECS, with students hesitating to share challenges and educators preferring traditional methods. These factors may impact the scale's outcomes and highlight the need for adaptation. Tailoring BLECS to diverse cultural contexts and aligning its language with local norms can improve its relevance. Cross-cultural studies could further refine the scale and provide deeper insights.

Abbreviations

BLECS: Perceptions of the Blended Learning Effectiveness and Challenges Scale, BLE: Blended Learning Effectiveness, TIEO: Technology Integration and Educational Outcomes, BLC: Blended Learning Challenges.

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Author Contributions

Saurabh Kalra: Conceptualization, Methodology. Nandini Srivastava: Writing – original draft, Review and Editing, Revised Manuscript Review, Supervision, Vandana Gambhir: Data curation, Software, Formal analysis, Review and approval, Revised Manuscript Review, Supervision.

Conflict of Interest

The authors have no conflict of interest.

Ethics Approval

Ethical review and approval were not applicable. All participants provided informed consent, and their data have been anonymized entirely.

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