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The Effects of Blended Learning Management and Student Engagement on Academic Achievement in Higher Vocational Colleges in Guangxi, China

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Abstract

The rapid digital transformation of vocational education has made blended learning a central instructional approach; however, empirical evidence on how Blended Learning Management (BLM) affects student engagement and academic achievement in higher vocational institutions is scarce. This study explores the direct and indirect effects of BLM on academic attainment in Guangxi higher vocational institutions, using student involvement as a mediator variable. A quantitative study was conducted on 480 full-time students from 10 public and private vocational colleges in 2024–2025. Representativeness across institution type, discipline cluster, and academic year was achieved through stratified quota sampling. SPSS was used for multiple regression and bootstrap-based mediation analyses. The study found that BLM positively predicts student engagement ($R^2 = 0.528$, $p < .001$), with significant benefits from technology integration, curriculum alignment, physical infrastructure, and educator proficiency. Academic achievement was positively correlated with student engagement ($R^2 = 0.475$, $p < .001$), with cognitive engagement being the largest predictor. BLM directly improves academic performance ($R^2 = 0.521$, $p < .001$). Student involvement partially mediated the association between BLM and academic achievement, as both direct and indirect impacts were statistically significant (95% bootstrap CI did not include zero). This study validates the vocational education management–engagement–achievement pathway, thereby advancing blended learning research. This study emphasises the necessity of blended learning management and engagement-focused instructional strategies to promote academic achievement in digitally transformed higher vocational institutions. Future research should include educational institutions from various areas and levels to improve the universality and external validity of the findings.

Keywords: Blended Learning Management, Student Engagement, Academic Achievement, Higher Vocational Education, Educational Production Function, Self-Determination Theory, Vocational Education Management

Introduction

Digital technology has drastically changed higher education teaching and learning, making blended learning the global standard. Educational Informatization and China Education Modernisation 2035 have advanced digital integration in vocational education in China, stressing the use of technology to improve instruction and learning. Higher vocational institutions help generate application-oriented talent for industrial upgrading and regional growth.

Blended learning, online and in-person instruction, is popular in vocational education. Research shows that blended learning improves student involvement and academic performance (Ashraf et al., 2021; De Bruijn-Smolders, 2024).

However, evidence reveals that learning outcomes vary widely between institutions, suggesting that blended learning efficacy depends more on design, coordination, and management than on instructional format ([Müller et al., 2023](#)).

Blended Learning Management helps to explain these disparities. It involves planning, organising, monitoring, and assessing online–offline instructional components such as learning objectives, teaching activities, assessment methodologies, interaction design, and feedback mechanisms. Practical skills, task sequencing, and competency-based assessment are important to vocational education; therefore, excellent management is essential for instructional coherence and learning continuity. Without proper supervision, blended learning can become superficial and fragmented.

Student engagement is well recognised as a significant factor in the way educational environments affect academic achievement. Learning engagement involves behavioural, emotional, and cognitive involvement ([Wong & Liem, 2022](#)). Blended settings offer flexibility and customisation, but higher vocational students struggle with learning motivation, self-regulation and sustained participation. These traits make instructional organisation and management quality crucial for engagement.

Despite the increased interest in blended learning, the literature on it is lacking. First, empirical studies on vocational education are scarce compared to those on general higher education or K–12. Second, while implementation quality is often acknowledged, Blended Learning Management is rarely conceptualised and empirically tested as a separate phenomenon. Third, student involvement is generally considered an outcome rather than a mediator between instructional management and academic accomplishment. Thus, the mechanisms by which management quality affects learning performance, especially in vocational contexts, remain unclear.

In Guangxi, the diverse curriculum and student demographics make higher vocational colleges ideal for filling these gaps. Good mixed courses—with clear task sequencing, logical assessment, and timely feedback—promote student engagement

and accomplishment, while weak courses fail to maximise blended learning’s potential.

Thus, this study examines how Blended Learning Management and student participation affect academic performance in Guangxi higher vocational colleges. This study expands blended learning research into vocational education and provides empirical data to improve instructional quality and assurance in digitally transformed vocational institutions by evaluating direct and intermediary linkages.

Research Objectives

- To examine the impact of Blended Learning Management on student engagement in Guangxi higher vocational colleges.
- To analyse the impact of student engagement on the academic achievement of Guangxi higher vocational college students.
- To identify the Blended Learning Management that impacts Guangxi higher vocational college students’ academic achievement..
- This study aimed to examine the mediating role of student engagement on the impact of Blended Learning Management on Guangxi higher vocational college students’ academic achievement.

Literature Review

Self-Determination Theory and the Educational Production Function underpin this study. Institutional inputs, instructional environments, and student learning behaviours affect learning outcomes such as academic achievement in EPF ([Todd & Wolpin, 2003](#); [Rivkin et al., 2003](#)). Blended Learning Management is a crucial instructional input, whereas student engagement is a behavioural mechanism that converts instructional conditions into academic outcomes. Self-Determination Theory outlines how well-managed learning environments meet students’ autonomy, competence, and relatedness demands, improving engagement and academic success. EPF and SDT provide a theoretical framework for studying the BLM-student engagement-academic achievement connection in higher vocational education.

The Relationship Between Blended Learning Management and Academic Achievement

A growing corpus of worldwide research has shown that blended learning, when handled well, can boost students' academic achievement across educational levels. Evidence shows that blended learning management, including instructional design, faculty digital competence, learning resources, and institutional support, determines learning outcomes, not technology.

Meta-analytical and systematic review studies have shown that well-designed blended learning environments outperform face-to-face training, especially in STEM and professional fields. These benefits stem from greater instructional flexibility, learning resource availability, and self-paced learning. Comparative experimental research in higher education shows that blended instructional methods boost post-test results, course grades, and information retention.

New international research reveals that blended learning indirectly improves academic performance by changing students' learning experiences. According to Community of Enquiry (CoI) studies, integrating teaching and social presence increases academic achievement by increasing engagement, collaborative enquiry, and motivation ([Adam et al., 2025](#)). Blended learning fosters student-centred pedagogies, active learning, and conceptual comprehension, which are linked to greater achievement in smart university contexts.

According to cross-national meta-analyses, blended learning affects academic achievement differently across contexts. When blended learning is implemented as a technological add-on rather than a coherent instructional strategy, institutional readiness, pedagogical design, faculty proficiency, and student support systems can reduce or eliminate the expected benefits ([Boelens et al., 2017](#)). These findings emphasise the role of blended learning management in modulating the instructional mode and learning outcomes.

Vocational education empirical research is limited. Domestic research implies that blended learning can improve students' autonomy, engagement, and academic achievement, but it frequently focuses on single teaching approaches or

learning outcomes rather than systematic managerial features. Thus, there is no empirical information on how integrated learning management components affect academic achievement, especially in higher vocational colleges.

Prior research provides a strong theoretical and empirical foundation tying blended learning to academic achievement, but it also highlights a fundamental gap: the need to investigate blended learning as a managed educational system, rather than an instructional style. Higher vocational education relies on instructional coherence, learner engagement, and digital-practical alignment; therefore, closing this gap is crucial.

H₁: Blended Learning Management positively influences students academic achievement.

The Relationship Between Student Engagement and Academic Achievement

Student engagement is an important predictor of academic success in educational environments. Empirical research has shown for five years that more involvement improves knowledge acquisition, skill development, learning efficiency, and academic achievement. Engagement is a multifaceted notion with behavioral, cognitive, and affective components that has been successful in higher education and occupational learning ([Fredricks et al., 2004](#)).

The link between engagement and academic performance is supported by vocational and higher-education data. In Chinese higher vocational colleges, behavioural engagement indicators such as class attendance, classroom interaction, and assignment completion positively affect grades, while emotional engagement improves learning enjoyment and indirectly supports academic achievement ([Yu et al., 2025](#)). These findings support the three-dimensional engagement model, highlighting behavioural, cognitive, and affective engagement in vocational education.

Recent studies have shown how participation affects academic achievement beyond direct benefits. Cognitive engagement increases deep learning, conceptual understanding, and critical thinking, making it the strongest predictor of academic performance across cultures. Behavioural engagement fosters consistent learning efforts and

task completion, whereas affective engagement indirectly boosts students' motivation, sense of belonging, and persistence. Higher student engagement promotes self-regulated learning, time management, and metacognitive monitoring, which improve academic performance (Cao, 2023).

Engagement–achievement strength depends on the circumstances. Recent systematic reviews have shown that learning environments, instructional design, and teacher support moderate engagement–academic success. Cognitive and behavioural engagement generally increase in blended and online learning, but timely teacher feedback and meaningful peer contact boost accomplishment (De Bruijn-Smolters & Prinsen, 2024). According to empirical studies on blended learning, student enthusiasm and engagement improve academic performance, especially in vocational education, which emphasises practical learning and applied skills (Fisher et al., 2021). Even when students are engaged, poor instructional advice, digital surroundings, or technological support may decrease the engagement–achievement link.

According to the literature, student engagement and academic accomplishment are linked at three levels. Engagement directly improves academic achievement through behavioral, cognitive, and affective participation. Second, participation indirectly affects motivation, self-regulation, and strategic learning. Third, learning modality, course characteristics, and instructional assistance affect how involvement leads to better academic performance. These findings improve our understanding of engagement processes and lay the groundwork for studying how student involvement improves academic performance in higher vocational education.

H₂: Student engagement positively influences academic achievement.

The Relationship Between Blended Learning Management and Student Engagement

A decade of research has shown that blended learning management (BLM) is crucial for student engagement. Beyond mixing online and face-to-face instruction, effective BLM stresses instructional design coherence, interactive learning structures,

faculty facilitation, and institutional support, which directly affect students' behavioural, cognitive, and affective engagement.

Systematic reviews and meta-analyses show that well-managed blended learning environments increase student engagement, especially when the instructional design promotes interaction, feedback, and learner autonomy. A comprehensive systematic review in Heliyon found that blended learning interventions with structured learning activities, such as flipped classrooms, online learning communities, and peer assessment mechanisms, increase multidimensional engagement, especially cognitive and affective engagement (De Bruijn-Smolters & Prinsen, 2024). These data show that educational organisation and management quality boost engagement more than technology do.

Global studies in higher education have shown that blended learning settings create student-centred and participatory learning experiences that engage students. According to Community of Inquiry (CoI) research, integrating instruction and social presence improves interaction quality, motivation, and sustained participation, which boosts student engagement (Adam et al. 2025). Quasi-experimental evidence from teacher education programmes shows that students exposed to blended learning management strategies participate more than those in traditional instruction, emphasising the importance of organizational arrangements and instructional coordination in engagement (Bekele et al., 2025).

Research also suggests that resource allocation, interaction support, feedback mechanisms, and learning platform functionality drive blended-learning engagement. According to research, students are more likely to work hard, persist, and participate in both online and offline learning when they perceive learning resources as accessible, instructional activities as coherent, and feedback as timely.

Domestic research has confirmed similar findings in local education. Recent Chinese research shows that blended teaching approaches improve classroom interaction, learning material organisation, and teacher–student communication, increasing students' behavioural, cognitive, and affective involvement. Regression-based analyses also show that students'

satisfaction with resource presentation, perceived learning gains, and self-efficacy positively affect engagement levels, suggesting that BLM platform design and instructional activities affect student engagement.

However, cross-national meta-analyses have warned that blended learning engagement is context-dependent. Some studies in China and the US report non-significant engagement gains, suggesting that poor implementation, misalignment with learners' backgrounds, or weak instructional integration can undermine blended learning's potential benefits (Bernard et al., 2014; Wong et al., 2024). These contradictions support the idea that blended learning management quality and contextual adaptation determine engagement.

The literature strongly suggests that integrated learning management improves student engagement. Effective BLM with rich digital resources, interactive instructional design, teacher assistance, and autonomous and collaborative learning increases students' behavioural participation, cognitive investment, and emotional connection to learning. Despite the expanding evidence in general higher education, empirical research on higher vocational institutions, particularly multidimensional engagement studies within a systematic management framework, is scarce. Advancing vocational blended learning theory and practice requires closing this gap.

H₃: Blended Learning Management has a positive and significant effect on Guangxi higher vocational college students' Academic Achievement

The Mediating Roll of Student Engagement on Blended Learning Management and Academic Achievement

In the past five years, international and domestic scholarship has agreed that student involvement mediates the relationship between blended learning management (BLM) and academic achievement. Recent studies regard engagement as a multifaceted learning process that transforms instructional and management input into quantitative academic output. Fredricks et al. (2004) defined student engagement as students' behavioural, cognitive, and affective investment in learning activities, which has

been validated across blended and online learning contexts (Fredricks et al., 2004).

Management and instructional research shows that BLM affects academic attainment by affecting students' learning experiences and engagement. Kahu (2013) believe that learning management systems' curriculum structure, interaction mechanisms, and feedback quality shape students' academic and psychosocial learning experiences and engage them. Teacher facilitation, peer connection, and well-designed learning activities improve students' behavioural and emotional involvement in blended learning environments (Martin & Bolliger, 2018). Importantly, some studies have demonstrated that instructional design or technology integration alone is insufficient without improved student engagement (Bond et al., 2020).

A large body of evidence links student engagement to academic success. Reviews and empirical studies have revealed that engaged students use deep learning strategies, persist in difficult activities, and perform better academically (Schindler et al., 2017). Recent systematic reviews in Heliyon and Education and Information Technologies show that cognitive engagement is the strongest predictor of academic achievement in blended and online learning, whereas behavioural and affective engagement indirectly boost learning persistence and motivation.

Following these findings, scientists have frequently used structural equation modelling and mediation analysis to examine the intermediary role of engagement. Bond et al. (2020) showed through a meta-analysis that student involvement mediates the impact of technology-supported learning on academic outcomes.

This mediating concept has gained empirical support in higher education and occupational contexts in domestic research. Cao (2023) found that blended teaching improves college students' learning gains, mostly through learning engagement, with the indirect effect outweighing the direct effect. Task-level analyses have also revealed that cognitive and emotional involvement differentially affect academic performance by learning activity and discipline. Students' strong practical focus and the importance of motivation and participation in skill-based learning make engagement a strong mediating factor in higher vocational colleges.

Self-efficacy and learning motivation have been added to the chain mediation or moderated mediation models in recent studies. These studies suggest that successful blended learning management boosts students' self-efficacy, motivation, engagement, and academic performance. These findings provide a more complex explanation of how managerial and instructional approaches affect learning outcomes via psychological and behavioural pathways.

Over the past five years, theoretical and empirical data have suggested that blended learning management improves academic performance through student involvement. Engagement is an essential process variable that relates classroom management techniques to learning outcomes and explains blended learning efficacy. This research supports the "blended learning management → student engagement → academic achievement" model but suggests further empirical research in higher vocational education contexts, where engagement-driven mechanisms may be more important.

H₄: Student Engagement has a significant mediating impact on Blended Learning Management and Guangxi higher vocational college students' Academic Achievement.

Framework

This study uses the Educational Production Function and Self-Determination Theory to define blended learning as an input–process–output system in higher vocational education. Research shows that blended learning performance depends on Blended Learning Management, including curriculum alignment, technology integration, infrastructure support, and educator proficiency. Students' behavioural, cognitive, and affective engagement during teaching has been shown to be a crucial predictor of academic success. Based on this theoretical and empirical base, this study claims that Blended Learning Management directly improves academic accomplishment and indirectly through student involvement.

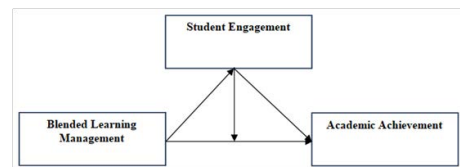


Figure 1 Conceptual Model

Methodology

This study adopted a quantitative research design using a structured questionnaire and statistical analysis to test the proposed theoretical model and hypotheses. The target population comprised full-time students enrolled in higher vocational colleges in Guangxi, China, during the 2024–2025 academic year. Ten institutions (six public and four private) were selected based on their national vocational college rankings. A stratified quota sampling method was employed according to institution type (public/private), discipline cluster, and academic year to ensure the sample's representativeness. With a population exceeding 187,000 students, the sample size was calculated using Yamane's formula at a 95% confidence level and a 5% margin of error, yielding a minimum of 400 respondents. To compensate for potential non-response, the final sample size was increased by 20%, resulting in 480 valid responses.

The Likert scale ranged from 1 = strongly disagree to 5 = strongly agree for all questionnaire items. Blended Learning Management, student engagement, and academic accomplishment were judged to be higher with higher scores. Composite variables for the statistical analysis were created by averaging the item scores for each construct.

Validity refers to the extent to which an instrument accurately measures the intended constructs. Content validity was ensured through an expert review by three specialists to confirm item relevance, clarity, and construct coverage. Construct validity was examined using a correlation analysis to assess the relationships among theoretically related variables. With a Cronbach's alpha of 0.967, the reliability scale was internally consistent. The pre-test findings show that all variables' alpha coefficients exceed 0.80, proving the questionnaire's reliability and quality, and preparing for the formal survey. Descriptive statistics provided an initial overview of the data, while correlation, analysis of variance (ANOVA),

and regression analyses were used to further support the validity of the measurement scales and to test the proposed hypotheses.

Data were collected through an online questionnaire distributed to students across participating vocational colleges via institutional platforms, emails, and social media channels. To enhance response rates, the questionnaire was designed to be concise and user-friendly, with modest participation incentives. Data quality was ensured through continuous monitoring and screening for completeness and consistency before analysis.

SPSS software was used for all the statistical analyses. Descriptive statistics were employed to summarise the sample characteristics, followed by correlation and regression analyses to test the proposed hypotheses (H1–H4). A mediation analysis was conducted to examine the indirect effects of the key variables, providing empirical support for the proposed research model.

Result

Table 1 Basic Information Statistics of Respondents

Projects	Category	Frequency	%
Gender	Male	235	49.00
	Female	245	51.00
Age	18-19	187	39.00
	20-21	227	47.30
	22-23	49	10.20
	≥ 24	17	3.50
Grade	Year 1	116	24.20
	Year 2	226	47.10
	Year 3	138	28.70
Type of school	Public	282	58.80
	Private	198	41.30
Major cluster	Mechanical / Manufacturing & Electrical	79	16.50
Major cluster	Digital Media / Art & Design	86	17.90
	Information Technology / AI / Software	98	20.40

Major cluster	Business Management / Finance / Logistics	69	14.40
	Transportation / Railway / Aviation	93	19.40
	Water & Electric Power / Civil / Energy	55	11.50
Extent of BLM	Not at all	24	5.00
	Limited	50	10.40
	Moderate	124	25.80
	High	216	45.00
	Fully implemented	66	13.80

Table 1 shows the respondents' demographics. Females (51.0%) slightly outnumbered males (49.0%) in the sample. As expected of higher vocational colleges, most respondents were 18–21 years old (86.3%) and in Year 2 (47.1%). Public institutions had the most participants (58.8%), and students came from a variety of key groups, with the largest numbers from information technology and transportation. Most respondents (84.6%) reported moderate to high levels of blended learning management deployment, indicating its widespread use across the sampled institutions.

Students rated Blended Learning Management, Student Engagement, and Academic Achievement as moderate across all categories. The mean Blended Learning Management ratings were 3.39–3.47, indicating adequate but improvable technology integration, pedagogy and curriculum alignment, physical infrastructure, and instructor proficiency. Student Engagement—including behavioural, cognitive, and affective components—showed moderate levels ($M = 3.36$ – 3.42), showing consistent participation and learning involvement without high intensity. Academic Achievement characteristics such as production, engagement, and role satisfaction had moderate perceptions ($M=3.35$ – 3.39), indicating stable learning outcomes with opportunities for improvement. The results suggest that while blended learning approaches are effective, tailored instructional management and engagement tactics can boost student success.

Table 2 Blended Learning Management- Descriptive Statistics

Dimension	Name	Mean	SD	Total
Blended Learning Management- Descriptive Statistics				
Technology Integration	This course's online learning platform rarely stalls or crashes.	3.47	1.12	3.47
	This course's online learning platform is accessible on computers and smartphones.	3.42	1.11	
	I can rapidly use the online learning platform because of its easy interface and functions.	3.48	1.12	
	Online course videos, slides, quizzes, and other resources load quickly and are user-friendly.	3.50	1.10	
Pedagogy & Curriculum	Course learning objectives are clear and easy to understand in the curriculum or online platform.	3.48	1.13	3.45
	This course's preview videos and online exams let me participate in face-to-face lectures.	3.40	1.14	
	Online and offline components of this course are similar in pace and difficulty, and the link feels natural.	3.49	1.15	
	Quizzes and assignments from online are fairly included in this course's final grade.	3.43	1.12	
Physical Infrastructure	The school's campus network and Wi-Fi satisfy my online learning needs.	3.39	1.09	3.39
	This course's multimedia classrooms (projector, speakers, etc.) are well-equipped for blended learning.	3.42	1.13	
	The school has computer rooms and study rooms for online learning and self-study, making online activities easy.	3.39	1.17	
	I can simply discover the correct staff or department to help with online learning platform or device issues.	3.37	1.11	
Educator Proficiency	A skilled instructor can upload materials, set tasks, and coordinate learning activities online.	3.44	1.10	3.44
	The teacher promptly answers students' online inquiries and posts on discussion forums.	3.43	1.10	
	Online learning data like assignment completion rates and quiz scores helps teachers alter classroom and tutoring tactics.	3.45	1.10	
	My teacher helps me use online tools like teaching videos and resource libraries to learn.	3.45	1.12	
Student Engagement - Descriptive Statistics				
Behavioral Engagement	Class is rarely missed since I always arrive on time.	3.33	1.17	3.36
	I pay attention in classes.	3.36	1.12	
	I actively participate in class discussions.	3.36	1.15	
	I complete homework and exercises after class using accessible resources.	3.39	1.15	
Cognitive Engagement	I consider real-world applications of what I study.	3.39	1.20	3.42
	fresh insights come from combining fresh and old information.	3.45	1.13	
	My learning style is rule memorization rather than comprehension. (reverse-keyed).	3.43	1.12	
	I concentrate on crucial points rather than skimming.	3.41	1.11	

Affective Engagement	I like to learn.	3.41	1.13	3.4
	I get bored or distracted in class.	3.41	1.13	
	I often feel good in class.	3.37	1.09	3.4
	The classroom climate is generally good.	3.41	1.07	
Academic Achievement - Descriptive Statistics				
Academic Output	High academic performance is my norm.	3.39	1.16	3.37
	I produce good results and relevant learning.	3.36	1.13	
	I learn and remember a lot.	3.37	1.12	
	I can translate my knowledge into practice.	3.37	1.15	
Academic Engagement	I work hard on assignments.	3.40	1.13	3.39
	I actively engage with professors and mentors.	3.36	1.15	
	I carefully read textbooks and related material.	3.39	1.15	
	I study a lot.	3.40	1.17	
Role Satisfaction	Study and personal life are balanced for me.	3.33	1.17	3.35
	I interact with peers inside and outside class.	3.36	1.18	
	I like my student identity and intellectual life.	3.36	1.20	
	I normally stay upbeat under academic pressure.	3.36	1.17	

Validity indicates the degree to which a measurement method can effectively and correctly measure the desired variable. In this study, SPSS software was used for factor analysis, and its detection indexes included the KMO and Bartlett tests. The KMO value ranges from 0 to 1, and the closer the value is to 1, the better it is for factor analysis. As shown in Table 4.7, the KMO value obtained in this questionnaire is .938 and the DF is 780, and the significance level of Bartlett's sphericity test is <.001, which indicates that the questionnaire data can be factor analysed.

Table 3 Validity Analysis Table

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.938
Bartlett's Test of Sphericity	Approx. Chi-Square	10716.8
	df	780
	Sig.	<.001

As can be seen from Table 4.8, the value of this questionnaire is 71.62%, which is greater than 60%; therefore, it is an available questionnaire.

Correlation Analysis

Correlation analysis is a statistical method used to study the correlation between two or more variables, which can be used to understand the correlation properties between variables. In this study, SPSS was used to verify the correlation between each variable, as well as the closeness and correlation direction.

As can be seen from the correlation analysis results in Table 4.10, all correlation coefficients are marked with *(* indicates $P < .05$) and all correlation coefficients are greater than 0. It means that there is a significant positive correlation between BLM, SE and AcA.

Table 4 Correlation Analysis

	TI	PC	PI	EP	BE	CE	AE	AO	AcE	RS
TI	1									
PC	.458**	1								
PI	.369**	.419**	1							
EP	.400**	.454**	.379**	1						
BE	.433**	.412**	.424**	.421**	1					

CE	.499**	.466**	.423**	.421**	.445**	1				
AE	.410**	.479**	.364**	.390**	.401**	.405**	1			
AO	.418**	.483**	.407**	.437**	.442**	.444**	.451**	1		
AcE	.395**	.473**	.399**	.404**	.402**	.417**	.374**	.460**	1	
RS	.451**	.450**	.387**	.411**	.413**	.466**	.427**	.390**	.441**	1

Regression Analysis

Numerous regression analyses examine the relationship between one dependent variable and numerous independent factors. This section examines three fundamental assumptions: 1)

How does Blended Learning Management (BLM) affect student engagement? 2) How does Student Engagement (SE) affect student engagement? 3) How does BLM affect academic achievement

Table 5 Multiple Regression Analysis

Model / Predictor Variables	β	Std. Beta	Std. Beta	t	p-value	VIF
Model 1: BLM $\rightarrow$ Student Engagement (H1)						
Technology Integration (TI)	.229	.029	.289	7.859	<.001	1.355
Pedagogy & Curriculum (PC)	.195	.030	.251	6.599	<.001	1.455
Physical Infrastructure (PI)	.178	.028	.231	6.432	<.001	1.295
Educator Proficiency (EP)	.168	.029	.209	5.709	<.001	1.351
Model fit	$R^2 = .528$	Adj. $R^2 = .524$	F = 132.584***	D-W = 2.083	Model fit	$R^2 = .528$
Model 2: Student Engagement $\rightarrow$ Academic Achievement (H2)						
Behavioral Engagement (BE)	.215	.031	.269	7.003	<.001	1.355
Cognitive Engagement (CE)	.261	.031	.326	8.473	<.001	1.340
Affective Engagement (AE)	.241	.032	.288	7.634	<.001	1.287
Model fit	$R^2 = .475$	Adj. $R^2 = .472$	F = 143.470***	D-W = 1.990	Model fit	$R^2 = .475$
Model 3: BLM $\rightarrow$ Academic Achievement (H3)						
Technology Integration (TI)	.199	.030	.241	6.518	<.001	1.355
Pedagogy & Curriculum (PC)	.230	.031	.284	7.416	<.001	1.455
Physical Infrastructure (PI)	.183	.029	.228	6.311	<.001	1.295
Educator Proficiency (EP)	.183	.031	.220	5.949	<.001	1.351
Model fit	$R^2 = .521$	Adj. $R^2 = .517$	F = 129.138***	D-W = 1.918	Model fit	$R^2 = .521$

Note. *** $p < .001$. BLM = BLM; D-W = Durbin-Watson statistic

The multiple regression findings for Hypotheses H1–H3 are presented in Table 5.

In Model 1, Blended Learning Management positively predicted student engagement across all four domains (Technology Integration, Pedagogy & Curriculum, Physical Infrastructure, and Educator Proficiency) ($\beta = .168-.289$, $p < .001$). The model explains 52.8% of the variance in Student Engagement, demonstrating its strength.

Model 2 shows that student engagement improves

academic performance. Cognitive Engagement is the most influential dimension ($\beta = .326$), followed by Affective and Behavioral Engagement. This model explains 47.5% of the variation in Academic Achievement.

In Model 3, Blended Learning Management predicts Academic Achievement, with Pedagogy & Curriculum being the most significant factors ($\beta = .284$). The model explains 52.1% of the variance in Academic Achievement. The variance inflation

factor (VIF) values were below 2.0 in all models, indicating no multicollinearity, and the Durbin–Watson statistics indicated residual independence.

The findings strongly support H1, H2, and H3, showing that Blended Learning Management improves Student Engagement, Student Engagement improves Academic Achievement, and Academic Achievement among Guangxi higher vocational college students.

Mediation Analysis

This study used SPSS PROCESS program Model 4 to test the mediating effect of student engagement (SE) between blended learning management (BLM) and academic achievement (AcA) through 5000 bootstrap sampling. This section presents the results of the mediation analysis from four aspects: total effect, direct effect, indirect effect, and Bootstrap confidence interval.

Table 6 Mediation Analysis of Student Engagement in the Relationship between Blended Learning Management and Academic Achievement

Effect Type	Effect (β)	SE / BootSE	t	p	LLCI	ULCI
Total Effect (BLM $\rightarrow$ AcA)	0.7973	0.0351	22.7422	<.001	0.7284	0.8662
Direct Effect (BLM $\rightarrow$ AcA, controlling SE)	0.5171	0.0478	10.8255	<.001	0.4233	0.6110
Indirect Effect (BLM $\rightarrow$ SE $\rightarrow$ AcA)	0.2802	0.0359	-	-	0.2109	0.3508
Standardized Indirect Effect	0.2533	0.0317	-	-	0.1923	0.3155

Note. Bootstrap = 5,000 samples; CI = 95%; BLM = Blended Learning Management; SE = Student Engagement; AcA = Academic Achievement

Table 6 delineates the mediation findings that investigated the influence of Student Engagement on the correlation between Blended Learning Management and Academic Achievement. The overall impact of BLM on Academic Achievement was favourable and statistically significant ($\beta = 0.7973$, $p < .001$), demonstrating a robust influence. Upon incorporating Student Engagement into the model, the direct effect of BLM persisted as significant ($\beta = 0.5171$, $p < .001$), indicating that BLM independently enhances students' academic performance.

The indirect effect of BLM on Academic Achievement through Student Engagement was substantial ($\beta = 0.2802$), with a 95% bootstrap confidence interval that excluded zero. The standardised indirect effect further validates the strength of this pathway. Given that both direct and indirect effects were statistically significant, Student Engagement was established as a partial mediator between Blended Learning Management and Academic Achievement. These studies demonstrate that BLM promotes academic attainment directly and indirectly by promoting increased student participation.

Discussion

This study investigated the relationships among Blended Learning Management (BLM), Student Engagement (SE), and Academic Achievement (AcA) in higher vocational colleges in Guangxi, China. Grounded in the Educational Production Function and Self-Determination Theory, this discussion interprets the findings according to each hypothesis and situates them within the existing literature.

Blended Learning Management Boosts Student Engagement Significantly

The results corroborate H1, which states that blended learning management boosts student engagement. Technology integration, pedagogy and curriculum alignment, physical infrastructure, and instructor proficiency all improved student engagement, but technology integration and curriculum alignment had the greatest impact on student engagement.

This supports past research showing that engagement in blended environments depends more on how learning resources, instructional activities, and teaching approaches are coordinated than on technology alone. The Educational Production Function views BLM as a crucial educational input

that shapes student learning. According to Self-Determination Theory, effective blended learning environments increase students' autonomy (flexible learning pathways), competence (clear objectives and feedback), and relatedness (teacher–student interaction), which motivates sustained participation.

These findings emphasise the importance of instructional coordination and managerial coherence in sustaining engagement across behavioural, cognitive, and affective dimensions in vocational education, where students often have heterogeneous academic preparedness and strong practice-oriented learning requirements.

Student Engagement Improves Academic Performance Significantly

Student engagement strongly predicted academic achievement in upper vocational students, supporting H2. Cognitive involvement was the strongest predictor, followed by affective and behavioural engagements.

This confirms that deep cognitive investment—meaningful processing, knowledge application, and reflective thinking—is a stronger predictor of academic success than surface-level participation alone. The Educational Production Function approach uses student participation to turn instructional inputs into educational outputs. These findings show that vocational students who are cognitively and emotionally invested in their studies are more likely to excel in knowledge acquisition and skill application.

Affective engagement emphasises the importance of pleasant learning emotions and classroom atmosphere in occupational settings. Vocational education is applied; thus, emotional connection and perceived relevance of learning activities seem to sustain learning effort and performance.

Blended Learning Management Improves Academic Performance Significantly

The results support H3, showing that Blended Learning Management directly and dramatically improves student performance. Pedagogy and curriculum alignment dominated BLM, followed by technology integration, physical infrastructure, and teaching proficiency.

This implies that the online-offline alignment of instructional material, learning activities, and assessment methodologies greatly affects blended vocational education academic attainment. An effective BLM reduces instructional fragmentation and ensures learning continuity, improving academic performance even without student engagement.

This supports the claim of the Educational Production Function that institutional and instructional inputs directly affect learning outputs. This shows that blended learning investments should prioritise instructional design quality and curricular coherence over technology.

Student Engagement Mediates Integrated Discussion

Mediation analysis sheds light on the effectiveness of blended learning beyond individual hypotheses. Student engagement partially mediated the blended learning management–academic achievement link. By increasing student participation, BLM directly and indirectly enhances academic performance.

This partial mediation helps to merge the EPF and SDT. BLM provides the institutional and management conditions for learning, but student engagement motivates and drives that learning. The presence of direct and indirect effects suggests that vocational education changes should target instructional management and student-centred engagement.

Summary of Discussion

The debate shows that good Blended Learning Management is essential for higher vocational education student engagement and achievement. Student involvement explains instructional management and learning outcomes, particularly cognitive and affective elements. The management–engagement–achievement pathway is theoretically and empirically explained by these findings, providing useful insights for digitally changed vocational education research and practice.

Limitations and Future Research

This study presents accurate and valid findings on the effects of blended learning management and student participation on academic achievement in

Guangxi higher vocational institutions; however, certain limitations should be addressed. The cross-sectional research approach of this study limits its potential to capture the dynamic changes in student engagement and academic accomplishment over time. Therefore, causal linkages and developmental patterns among the variables cannot be studied completely.

Second, this survey only included higher vocational colleges in Guangxi. Regional features, institutional contexts, and educational environments may affect the results, limiting their applicability to other locations or to higher education institutions. Third, student self-reported questionnaires captured most of the data. The measurement scales were reliable and valid, although using a single data source may have caused common method bias and social desirability effects, which could have affected answer accuracy. Due to these restrictions, numerous research areas have been suggested. Longitudinal studies may investigate the evolution of blended learning management, student involvement and academic accomplishment. Researchers may also sample institutions from different areas and educational levels to improve the external validity and generalisability of the findings.

Future studies may also include learning analytics, platform log data, classroom observations, and interviews to further understand students' learning and engagement processes.

Finally, the theoretical model of this study emphasises blended learning management, student involvement, and academic accomplishment. Learning motivation, digital literacy, teacher support, and learning strategies should be added to future studies to investigate their mediating or moderating functions and construct a more comprehensive theoretical framework.

Contribution

Theoretical Contribution, This research includes significant theoretical advances in blended learning and vocational education. First, it expands blended learning management research beyond general higher education and K–12 to higher vocational education, which has practice-oriented curricula and different learning profiles. This study improves the theoretical

knowledge of digital teaching transformation in vocational education, where empirical evidence is scarce.

Second, this study explicitly incorporates student engagement as a major process variable linking instructional inputs to learning outputs, advancing the theory of Educational Production Function. This study validates the pathway of blended learning management-student engagement-academic achievement, strengthening the “teaching management-learning process-learning outcomes” concept and clarifying the behavioural and psychological mechanisms linking instructional management to academic performance.

Third, Self-Determination Theory and mixed learning management views are used to explain learning success in multiple dimensions. Instructional management defines learning structures, whereas self-determination theory explains how these structures promote behavioural, cognitive, and emotional engagement. This integration enhances the theoretical understanding of blended vocational learning student motivation.

Finally, by using multidimensional measures of student engagement and academic achievement, including knowledge mastery, skill development, and learning efficiency, this study goes beyond single-outcome models and provides a more comprehensive theoretical framework for vocational-learning-outcome research.

This report offers evidence-based advice for implementing and improving blended learning in higher vocational colleges. The results show that curricular coherence and instructional alignment across online and offline components improve student engagement, emphasising the necessity of rigorous curriculum preparation and integrated learning design.

The results also emphasise the importance of digital competency among educators, indicating that vocational schools should invest in continuing professional development, including pedagogy, curriculum design, and educational technology training. Shared digital resource portals and blended model courses can improve teaching.

The study also stresses the importance of institutional infrastructure, including robust network

systems, accessible learning platforms, and helpful technical services, in generating reliable learning environments that encourage student involvement.

After identifying student engagement as a major mediating mechanism, the study emphasises the need for interactive teaching tactics, meaningful task design, and timely feedback to increase behavioural, cognitive, and emotional engagement. These insights can help educators, administrators, and legislators improve academic attainment and vocational education quality through data-driven decision-making.

Conclusion

Blended Learning Management (BLM) and student engagement (SE) affect academic achievement (AE) in Guangxi higher vocational colleges. The findings suggest that the BLM significantly increases student engagement and academic performance. Cognitive participation has the greatest impact on academic performance. Student engagement partially mediates the link between BLM and AE, showing that effective blended learning management increases student engagement and success.

These findings support vocational education management (BLM)–engagement (SE)–achievement (AE) and highlight the importance of integrated learning environments. Technology, curricular alignment, institutional support, and teacher competence can improve student engagement and learning in digitally transformed educational settings.

This study strengthens blended learning (BL) research in higher vocational education and improves teacher management and student learning outcomes.

Conflict of Interest

The authors declare that they have no knowledge of competing financial interests or personal relationships that could have influenced this study.

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Ethics Approval

As this study was a non-invasive questionnaire survey without sensitive personal data or experimental procedures, ethical approval was not required. Participation in this study was voluntary

and anonymous. All respondents were informed of the study's goals and provided informed consent before data collection.

AI Technology

The manuscript was edited, organised, and clarified using AI. The authors are responsible for the content, interpretation, and conclusions of this study.

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