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The Role of Blackboard Technology towards Student's Performance and Satisfaction Evaluation

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ABSTRACT
This study examines the intricate relationship of teaching methods, institutional infrastructure, student participation, and Blackboard technology in higher education. Its objective is to determine how these factors collectively impact student accomplishment and satisfaction. Based on a thorough examination of existing research, a conceptual framework is developed. In this framework, teaching methods and institutional support are considered independent factors, while student engagement is seen as a mediating component. In addition, Blackboard technology is added as a moderating variable. Analyzed using Structural Equation Modelling (SEM), data from 383 participants across five Saudi universities is utilized. The findings reveal important connections between the variables, emphasizing the crucial influence of student involvement and the moderating effect of Blackboard technology. The study used SEM to clarify the intricate mechanisms by which these components interact, providing useful insights into the enhancement of educational settings. This research contributes to improving student performance and satisfaction in modern higher education contexts by providing information on strategic interventions and pedagogical approaches.

Keywords: Teaching modes, Institutional infrastructure, Student engagement, Blackboard technology, Higher education

I. INTRODUCTION

The landscape of education has undergone significant transformation in recent years, driven by advancements in technology and evolving pedagogical (Q Islam and Faisal Ali Khan 2023; Yan and Li 2023). Blended learning, which combines traditional face-to-face instruction with online learning modalities, has emerged as a promising framework for delivering education that is flexible, personalized, and responsive to the needs of diverse (Hrastinski 2019; Qamrul Islam and Ali Khan 2024b). In the context of Saudi Arabia's ambitious Vision 2030 plan, which prioritizes the development of a modern and globally competitive education system, the integration of technology in education has become a key focus area(Alessa, Shalhoob, and Almugarry 2022). To foster a knowledge-based economy and equip students with the skills needed to thrive in the digital age, there is growing interest in exploring the effectiveness of blended learning environments in Saudi Arabian universities.

Saudi Arabia's Vision 2030 plan seeks to diversify the economy, modernize society, and invest in human capital, with education playing a central role in achieving these objectives. The plan envisions the development of a world-class education system that can meet the demands of a rapidly changing global landscape. As part of this effort, technology has been identified as a critical enabler of education, with a particular emphasis on e-learning and blended learning approaches. Blended learning, which combines the best elements of traditional classroom teaching with the flexibility and accessibility of online learning, holds immense potential for enhancing the quality and accessibility of education in Saudi Arabia(Mitchell and Alfuraih 2018).

However, despite the increasing adoption of blended learning models, there remains a need for empirical research to assess their effectiveness and identify factors that contribute to student achievement and satisfaction. This gap in the literature is particularly pronounced in the context of Saudi Arabian universities, where the implementation of blended learning approaches is still relatively nascent. Therefore, this study seeks to address this gap by investigating the role of blended learning environments in Saudi Arabian universities and their impact on student outcomes.

The study aims to explore the effectiveness of blended learning environments in Saudi Arabian universities by examining their impact on student achievement and satisfaction. Specifically, the study will compare the academic performance and satisfaction levels of students enrolled in traditional classroom courses with those enrolled in hybrid courses that utilize blended learning approaches. By investigating the relationship between instructional modalities and student outcomes, the study aims to provide insights into the factors that contribute to successful learning experiences in blended learning environments.

Moreover, the study will also examine the role of technology, particularly Blackboard technology, in facilitating blended learning experiences. Blackboard technology, an online learning management system widely used in educational institutions, offers a platform for communication, collaboration, and content delivery in blended learning environments. By investigating the effectiveness of Blackboard technology in enhancing student achievement and satisfaction, the study aims to provide practical recommendations for educators and policymakers seeking to leverage technology to improve educational outcomes.

The study aims to contribute to the growing body of research on blended learning in the context of Saudi Arabian universities. By investigating the effectiveness of blended learning environments and the role of technology in supporting these environments, the study seeks to provide evidence-based insights that can inform educational policies and practices, ultimately enhancing the quality and accessibility of education in Saudi Arabia.

II. REVIEW LITERATURE

In recent years, blended learning has emerged as a popular approach to education, combining traditional face-to-face teaching with online learning(Cronje 2020; Suhluli and Ali Khan 2022). Blackboard technology has played a vital role in facilitating blended learning by providing a virtual learning environment where students and teachers can communicate, collaborate, and access course materials online(Hakami et al. 2023; Kleinveldt, Schutte, and Stilwell 2016).Several studies have investigated the effectiveness of blended learning and the impact of Blackboard technology on student learning outcomes and satisfaction(Yamagata-Lynch 2014). One study conducted in Saudi Arabia found that blended learning using Blackboard technology improved student performance and engagement compared to traditional classroom teaching(The Use of Learning Management System (LMS): Are we 'using' it right? 2021).Similarly, a study in the USA found that Blackboard technology improved student satisfaction and motivation in a blended learning environment(Uziak et al. 2018). Another study in Malaysia found that blended learning using Blackboard technology improved student learning outcomes and satisfaction compared to traditional classroom teaching(Wai Yee and Cheng Ean 2020).However, some studies have reported mixed findings. For example, a study in Thailand found that while Blackboard technology-enhanced student engagement, it did not improve learning outcomes(Kumar et al. 2021). Similarly, a study in New Zealand found that while Blackboard technology improved student satisfaction, it did not have a significant impact on student learning outcomes(Tuapawa 2017).Despite these mixed findings, there is a clear consensus among researchers that Blackboard technology can enhance the effectiveness of blended learning by providing a flexible and accessible virtual learning environment. However, more research is needed to explore the specific factors that influence the effectiveness of Blackboard technology in blended learning environments, such as the role of teacher support, student readiness, and Blackboard Technology (Zaneldin, Ahmed, and El-Ariss 2019).

In the context of Saudi Arabia's Vision 2030, which emphasizes the importance of modernizing the education system and promoting the use of technology in education, exploring the effectiveness of Blackboard technology in blended learning environments is particularly relevant. This study aims to address the research gap in the literature by comparing the effectiveness of traditional classroom teaching and hybrid courses using Blackboard technology on student achievement and satisfaction in Saudi Arabian universities

Institutional Infrastructure

Institutional infrastructures, such as reliable internet access and up-to-date technology, are critical factors in enhancing students' learning experiences. Lack of access to institutional infrastructures can lead to a digital divide, which can disproportionately affect students from disadvantaged backgrounds(Abugre 2018). Studies have shown that students who have access to institutional infrastructures have higher levels of engagement and motivation, leading to improved academic performance. Therefore, educational

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institutions need to prioritize the provision of adequate institutional infrastructure to ensure that all students have equal opportunities for academic success(Almurayh et al. 2022; Medabesh and Khan 2020).
H1: Institutional Infrastructure has a significant impact on Student Achievement
H2: Institutional Infrastructure has a significant impact on Student Satisfaction

Mode of Teaching
Traditional Classroom Teaching

Traditional classroom teaching, characterized by face-to-face interaction between instructors and students, has long been the predominant mode of instruction in educational institutions. Proponents of this approach argue that it fosters direct communication, promotes active participation, and facilitates immediate feedback, thereby enhancing student learning outcomes (Graham et al., 2020). However, critics point to its limitations, such as limited flexibility, one-size-fits-all instruction, and challenges in accommodating diverse learning styles and preferences (Chen et al. 2023)(McGill et al., 2018).

Blended Learning

Blended learning, which combines traditional face-to-face instruction with online learning components, has gained traction as an alternative teaching mode in recent years. This approach offers the benefits of both in-person interaction and digital resources, providing students with greater flexibility, personalized learning experiences, and access to a variety of multimedia materials (Means et al., 2013). Research indicates that blended learning can lead to improved student achievement and satisfaction compared to traditional classroom teaching (Freeman et al., 2019). Moreover, the flexibility inherent in blended learning environments has been shown to promote higher levels of student engagement (Hrastinski 2019)(Qamrul Islam and Ali Khan 2024b).
H3: Mode of teaching has a significant impact on Student Performance.
H4: Mode of teaching has a significant impact on Student Satisfaction.

Blackboard technology

Blackboard technology has been widely used in various academic institutions as an online learning platform(Kumar et al. 2021). It has been found to have a positive impact on student learning outcomes and overall satisfaction(Sultana 2020). Research has shown that the use of Blackboard technology can facilitate student engagement, collaboration, and communication, as well as provide access to a variety of learning resources(Shah and Barkas 2018). Moreover, Blackboard technology has been found to promote personalized learning experiences, allowing students to learn at their own pace and according to their own learning styles(Carvalho, Areal, and Silva 2011). However, some studies have also pointed out the importance of effective training and support for both students and instructors in using Blackboard technology to its full potential. Overall, Blackboard technology can be a valuable tool in enhancing student learning outcomes and improving the quality of education.

Student engagement

Student engagement refers to the degree of involvement, motivation, and active participation in the learning process (Et.al 2021). It encompasses both cognitive and affective aspects, including attention, interest, curiosity, and enthusiasm. Engaged students are more likely to take ownership of their learning, apply critical thinking skills, and collaborate with peers. Active learning approaches, such as problem-based learning and project-based learning, have been shown to increase student engagement and improve learning outcomes(Shehawy and Ali Khan 2024).
H5: Student Engagement mediates the relationship between mode of teaching and Student Achievement.
H6: Student Engagement mediates the relationship between the mode of teaching and Student satisfaction.
H5: Student Engagement mediates the relationship between Institutional Infrastructure and Student Achievement.
H6: Student Engagement mediates the relationship between Institutional Infrastructure and Student satisfaction.

Student satisfaction

Student satisfaction refers to the overall experience of the learner with the course content, delivery, and instructor feedback(Wong and Chapman 2022). It is a critical component of student motivation and persistence in the learning process. Higher levels of satisfaction have been linked to improved learning outcomes, including higher grades and increased retention rates(Darawong and Widayati 2022). Research has shown that factors such as clear course goals and objectives, effective communication, timely feedback, and relevant and engaging content can contribute to higher levels of student

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satisfaction(Abidi and Faisal AU Khan 2018; Choe et al. 2019; Qamrul Islam and Ali Khan 2024a).

The framework of the study as shown in Figure 1 has been developed to examine the intricate relationship between many factors that impact student outcomes in higher education, based on a thorough analysis of existing literature. The theory suggests that the style of study and institutional infrastructure are the main independent variables that directly impact student achievement and satisfaction. Furthermore, student engagement is defined as a mediating factor that connects instructional methods and academic results by measuring the level of active involvement and participation in the learning process. Moreover, the Blackboard technology is presented as a moderating factor that either enhances or diminishes the impact of the study mode on student results, depending on how it is used and how effective it is. This study aims to analyze the complex connections between teaching methods, institutional support, student involvement, and technological interventions. The goal is to gain a better understanding of how these factors impact student achievement and happiness in higher education settings. The findings will be used to improve educational practices and policies.

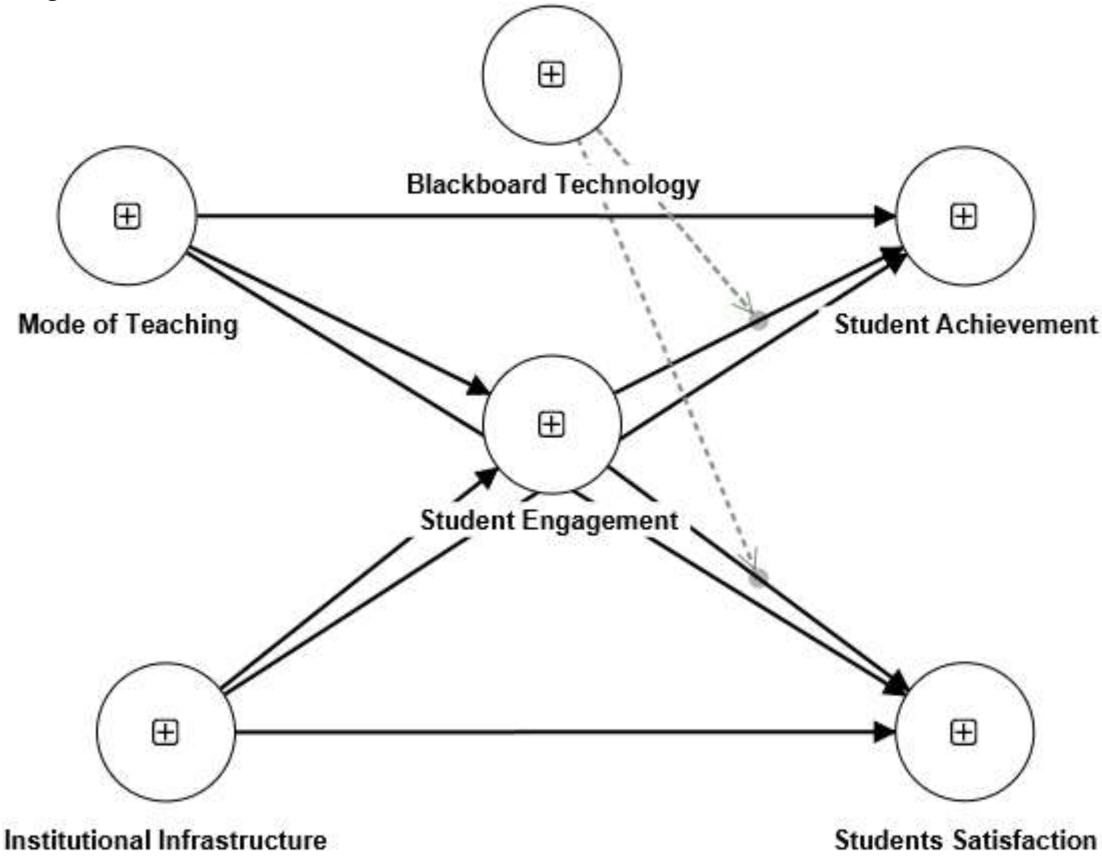

Figure 1: Framework of the Study

III. METHODOLOGY

This research aims to quantitatively explore the Role of Blackboard Technology in student's Performance and Satisfaction Evaluation. Employing a Structural Equation Modeling (SEM) approach with Smart PLS 4, the study seeks to comprehensively understand the relationships among various variables affecting student outcomes(Hooper, Coughlan, and Mullen 2008).

Sampling Procedure:

To ensure representation across diverse institutional contexts, five Saudi universities are purposively selected. A total of 383 participants, including students and teachers, are sampled from these universities using simple random sampling. This sample size is chosen to achieve adequate statistical power and enhance the generalizability of findings across different disciplines and institutions.

Data Collection

Data collection for this study was conducted using Google Forms, a widely accessible and efficient platform for survey administration. The process began with the design and development of survey instruments tailored to capture relevant variables about the research objectives. These surveys were meticulously crafted to elicit responses from both students and teachers across five Saudi universities, ensuring comprehensive coverage of perspectives within the blended learning landscape. Upon completion of survey development, the instruments were integrated into Google Forms, allowing for easy distribution and data collection. Participants were invited to access the surveys electronically via email or other communication channels. Before survey dissemination, ethical considerations were carefully addressed, including the assurance of confidentiality and the acquisition of informed consent from all participants. Throughout the data collection period, diligent efforts were made to encourage participation and maximize response rates, thereby enhancing the representativeness and reliability of the findings. Additionally, regular monitoring and follow-up were conducted to address any technical issues or concerns raised by participants. Overall, the utilization of Google Forms facilitated a streamlined and accessible approach to data collection, enabling the study to gather valuable insights from a diverse array of stakeholders in Saudi Arabian universities.

IV. DATA ANALYSIS:

Data analysis is done using SEM–PLS asit offers a comprehensive framework for analyzing complex relationships among multiple variables, making it suitable for this study. Smart PLS 4 is chosen for its flexibility in handling small sample sizes and exploratory research. It allows for both measurement and structural model analysis within a single integrated framework, facilitating a thorough examination of research hypotheses.

The analysis comprises two main components: the measurement model and the structural model.

Measurement Model

The measurement model evaluates the validity and reliability of constructs measured in the study. Convergent validity, assessing the extent to which indicators measure their respective constructs consistently, is examined using Smart PLS 4. This involves calculating the loadings of indicators on their constructs and assessing their significance. Discriminant validity, which ensures that constructs are distinct from one another, is also assessed through Smart PLS 4. This entails comparing the square roots of the Average Variance Extracted (AVE) with the inter-construct correlations(Ringle and Sarstedt 2016).

Structural Model

The structural model investigates the relationships among latent variables. It tests hypothesized relationships between independent variables (teaching mode, institutional infrastructure) and dependent variables (student achievement, satisfaction), as well as potential mediating effects. Smart PLS 4 estimates path coefficients and tests their significance using bootstrapping techniques(Hanafiah 2020).

In addition to the main analyses, several supplementary statistical techniques were employed to further explore the relationships among variables and assess the overall fit and significance of the model. Firstly, the R-square (R^2) statistic was utilized to quantify the proportion of variance explained by the model. A higher R-square value indicates a stronger fit of the model to the observed data, signifying that the independent variables collectively account for a larger portion of the variation in the dependent variables. This metric serves as a crucial indicator of the model's explanatory power and overall effectiveness in capturing the underlying relationships(Hooper, Coughlan, and Mullen 2008).

Furthermore, the F-test (F-statistic) was employed to evaluate the overall significance of the model. This statistical test assesses whether the explained variance in the dependent variables is significantly different from zero, providing insight into the overall predictive capability of the model. A significant F-test result indicates that the independent variables collectively have a significant impact on the dependent variables, further validating the model's relevance and utility in explaining the phenomena under investigation(Henseler, Hubona, and Ray 2016).

Additionally, bootstrap resampling techniques were utilized to estimate the standard errors of path coefficients and test their significance. Bootstrap resampling involves repeatedly sampling data from the observed dataset with replacement, allowing for the calculation of standard errors and confidence intervals for parameter estimates. By generating multiple bootstrap samples and analyzing the distribution of parameter estimates, robust estimates of parameter values can be obtained, enhancing the reliability and stability of the results. This approach provides valuable insights into the precision of parameter estimates and helps mitigate potential biases arising from sample variability, thereby bolstering the credibility and generalizability of the findings. Overall, the inclusion of these supplementary analyses enriches the statistical rigor of the study and facilitates a comprehensive understanding of the complex relationships among variables in the research model.

Robustness of the Model

In conducting a robustness check for our study, we meticulously examined several key aspects to ensure the integrity and reliability of our findings. Firstly, we reassessed convergent validity by scrutinizing the consistency and reliability of our measurement model. This involved reevaluating the relationships between observed indicators and their respective latent constructs to confirm their alignment and accuracy. Additionally, we reiterated our assessment of discriminant validity to confirm that each construct in our model measures distinct and separate concepts. We further examined the goodness of fit of our structural model by revisiting measures such as R-square and F-square values, which indicate the proportion of variance explained by the model and the effect size of the predictors, respectively. Furthermore, we scrutinized the Variance Inflation Factor (VIF) (POTTERS 2022)values to ensure that multicollinearity among predictor variables did not unduly influence our results. Through these rigorous checks, we verified the robustness of our study's findings and bolstered confidence in the validity and reliability of our conclusions Refer to Annexure III.

V. DATA ANALYSIS AND INTERPRETATION

Measurement Model

In our study investigating the impact of Blackboard technology in blended learning environments within Saudi Arabian universities, the measurement model serves as a crucial component for ensuring the validity and reliability of our research findings. This model entails a systematic evaluation of how well the observed variables align with the latent constructs identified in our study framework. Through careful construct definition, indicator selection, and assessment of convergent and discriminant validity, we aim to establish the accuracy and consistency of our measurement instruments. Utilizing Smart PLS 4 software, we analyze the loadings of indicators on their respective constructs to assess convergent validity, ensuring that each indicator effectively captures the intended construct. Furthermore, we evaluate discriminant validity by comparing the square roots of the Average Variance Extracted (AVE) with inter-construct correlations, ensuring that constructs are distinct from one another. Additionally, reliability assessment using measures such as Cronbach's alpha coefficient ensures the internal consistency and stability of our measurement instruments. By rigorously evaluating the measurement model, we lay a solid foundation for producing reliable and valid measures, thus facilitating robust analyses and meaningful insights into the complex relationships among variables in our study as illustrated in Figure 2.

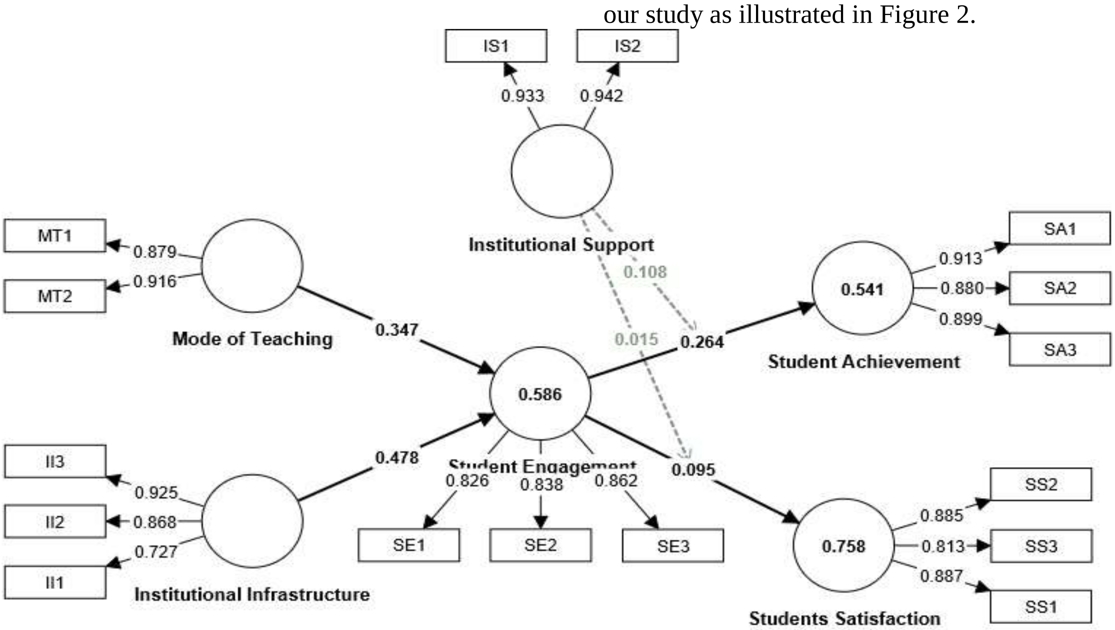

Figure 2- Measurement Model

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Table 1: Convergent Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Institutional Infrastructure	0.792	0.810	0.880	0.712
Blackboard Technology	0.863	0.866	0.936	0.879
Mode of Teaching	0.760	0.776	0.892	0.806
Student Achievement	0.879	0.879	0.925	0.805
Student Engagement	0.795	0.799	0.880	0.709
Students Satisfaction	0.827	0.835	0.897	0.744

Table 1 presents the results of the convergent validity assessment for each latent construct in our study, including Institutional Infrastructure, Blackboard Technology, Mode of Teaching, Student Achievement, Student Engagement, and Student Satisfaction. To evaluate convergent validity, we consider several key metrics: Cronbach's alpha, composite reliability (rho_a and rho_c), and average variance extracted (AVE).

Cronbach's alpha measures the internal consistency of the indicators within each construct, with values ranging from 0 to 1. Typically, values above 0.7 are considered acceptable, indicating a reliable set of indicators. In our study, all constructs exceed this threshold, with values ranging from 0.760 to 0.879. This suggests that the indicators within each construct are internally consistent, demonstrating reliability in measuring the intended construct. Composite reliability (rho_a and rho_c) assesses the reliability of the overall construct, considering both shared and unique variance among indicators. Values above 0.7 are generally considered acceptable, indicating sufficient reliability. In our study, both rho_a and rho_c values range from 0.776 to 0.879, surpassing the threshold, indicating strong reliability in measuring each construct. Average variance extracted (AVE) represents the amount of variance captured by the construct relative to the measurement error. AVE values above 0.5 are typically considered acceptable, indicating good convergent validity. In our study, all constructs exhibit AVE values ranging from 0.709 to 0.879, well above the threshold, demonstrating that a significant proportion of variance is captured by the construct relative to measurement error.

Overall, the results indicate strong convergent validity across all constructs, as evidenced by high values of Cronbach's alpha, composite reliability, and AVE. These findings provide confidence in the reliability and validity of our measurement instruments, supporting the accuracy of our research model and subsequent analyses.

Table 2: Discriminant Validity – Fornell Larker Criterion

	Institutional Infrastructure	Blackboard Technology	Mode of Teaching	Student Achievement	Student Engagement	Students Satisfaction
Institutional Infrastructure	0.844					
Blackboard Technology	0.713	0.938				
Mode of Teaching	0.717	0.788	0.897			
Student Achievement	0.799	0.707	0.71	0.897		
Student Engagement	0.727	0.812	0.69	0.665	0.842	
Students Satisfaction	0.683	0.869	0.765	0.687	0.738	0.862

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Table 2 presents the results of the discriminant validity assessment using the Fornell-Larcker criterion, which compares the square root of the average variance extracted (AVE) for each construct with the correlations between constructs. The diagonal elements represent the square root of the AVE for each construct, while the off-diagonal elements represent the correlations between constructs. According to the Fornell-Larcker criterion, discriminant validity is established when the square root of the AVE for each construct is greater than the correlations between that construct and all other constructs in the model. Upon examining the diagonal elements, we observe that the square root of the AVE for each construct exceeds the correlations between that construct and all other constructs in the model, indicating discriminant validity for each construct. This suggests that each construct is distinct from the others and is measuring a unique underlying concept. For example, consider the construct "Institutional Infrastructure." The square root of its AVE (0.712) is greater than the correlations between "Institutional Infrastructure" and other constructs (ranging from 0.683 to 0.844), confirming its discriminant validity. This pattern is consistent across all constructs, reinforcing the distinctiveness of each construct in our measurement model.

Overall, the results of the discriminant validity assessment support the validity of our measurement model, indicating that each construct effectively captures a unique aspect of the phenomena under investigation. This strengthens our confidence in the reliability and validity of the constructs measured in our study.

Table 3: Comparison of Variance Inflation Factor (VIF) Values between Saturated and Estimated Models

	VIF
II1	1.349
II2	2.651
II3	3.052
IS1	2.357
IS2	2.357
MT1	1.602
MT2	1.602
SA1	2.764
SA2	2.175
SA3	2.518
SE1	1.630
SE2	1.697
SE3	1.744
SS1	2.140
SS2	2.123
SS3	1.636
Blackboard Technology x Student Engagement	1

	Saturated model	Estimated model
SRMR	0.085	0.113
d_ULS	0.982	1.74
d_G	0.952	1.128
Chi-square	1857.06	2033.915
NFI	0.677	0.647

Table 3 presents a comparison of Variance Inflation Factor (VIF) values, along with model fit indices, between the saturated and estimated models. VIF values provide insight into multicollinearity within the model, with higher values indicating potential issues. In the saturated model, VIF values range from 1.349 to 3.052, suggesting moderate to low levels of multicollinearity among the variables. However, in the estimated model, VIF values vary, with some variables showing increases compared to the saturated model. Notably, variables such as II2 and II3 exhibit higher VIF values in the estimated model, indicating potential multicollinearity concerns. Additionally, model fit indices such as the Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), and Normal Fit Index (NFI) are provided for both models. These indices assess the overall fit of the model to the data, with lower values indicating better fit. Overall, the comparison highlights differences in multicollinearity and model fit between the saturated and estimated models, suggesting potential areas for further investigation and model refinement.

Table 4: F-square and R-square Values for Saturated and Estimated Models

	f-square		R-square	R-square adjusted	R-square adjusted
Institutional Infrastructure -> Student Engagement	0.268	Student Achievement	0.541	0.538	0.538
Blackboard Technology-> Student Achievement	0.190	Student Engagement	0.586	0.584	0.584
Blackboard Technology-> Students Satisfaction	0.883	Students Satisfaction	0.758	0.756	0.756
Mode of Teaching -> Student Engagement	0.141				
Student Engagement -> Student Achievement	0.052				
Student Engagement -> Students Satisfaction	0.013				
Blackboard Technology x Student Engagement -> Student Achievement	0.038				
Blackboard Technologyx Student Engagement -> Students Satisfaction	0.001				

Table 4 displays the F-square values for various relationships within the estimated model. These values quantify the proportion of variance in the dependent variable explained by the independent variable(s) in each relationship. For instance, Institutional Infrastructure explains 26.8% of the variance in Student Engagement, while Blackboard Technology accounts for 19% of the variance in Student Achievement. Notably, the relationship between Blackboard Technology and student satisfaction demonstrates a substantial explanatory power, with Blackboard Technology elucidating 88.3% of the variance in student satisfaction. Conversely, some relationships, such as Student Engagement's impact on student satisfaction, exhibit lower F-square values, suggesting a limited role in explaining variance. Moreover, interaction effects, like the interplay between Blackboard Technology and Student Engagement, reveal modest contributions to variance in outcomes, albeit with varying degrees of significance. These F-square values offer valuable insights into the relative influence of independent variables and interactions on dependent variables within the estimated model, aiding in the discernment of their respective contributions to the overall model fit and explanatory power.

The R-square values for three dependent variables within the estimated model. R-square, a measure of the proportion of variance in the dependent variable explained by the independent variables, provides valuable insights into the model's overall explanatory power. For Student Achievement, the R-square value is 0.541, indicating that the independent variables collectively account for 54.1% of the variance in Student Achievement. Similarly, for Student Engagement, the R-square value is 0.586, suggesting that the independent variables explain 58.6% of the variance in Student Engagement. Notably, for student satisfaction, the R-square value is substantially higher at 0.758, indicating that the independent variables explain 75.8% of the variance in student satisfaction. The adjusted R-square values, which consider the model's complexity and number of predictors, remain consistent across all three dependent variables. These findings underscore the effectiveness of the estimated model in capturing and explaining the underlying relationships, thus providing valuable insights into the predictors of Student Achievement, Student Engagement, and Students Satisfaction within the context of the study.

Structural Model

In the structural model of our study, we aim to examine the relationships between various latent constructs and their impact on student outcomes within blended learning environments. The structural model elucidates the pathways through which independent variables influence dependent variables and allows us to understand the complex interplay among different factors.

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In our study, the structural model includes latent constructs such as Institutional Infrastructure, Blackboard Technology, Mode of Teaching, Student Engagement, Student Achievement, and Students Satisfaction. These constructs represent key aspects of the educational environment, including the quality of institutional resources, support systems, teaching methods, student engagement levels, academic achievement, and overall satisfaction with the learning experience.Our hypothesized relationships within the structural model include the impact of Institutional Infrastructure and Blackboard Technologyon Student Engagement, Student Achievement, and student satisfaction. Additionally, we investigate the influence of the Mode of Teaching on Student Engagement and its subsequent effects on Student Achievement and student satisfaction.Through structural equation modeling (SEM), we analyze the direct and indirect effects of these latent constructs on student outcomes. SEM allows us to simultaneously estimate multiple relationships and account for measurement error, providing a comprehensive understanding of the complex dynamics at play in blended learning environments.The structural model serves as a framework for testing our hypotheses and examining the relative importance of different factors in predicting student achievement and satisfaction. By elucidating these relationships, our study contributes to the broader understanding of effective educational practices and informs the development of strategies to enhance student learning experiences in blended learning settings as illustrated in Figure 3.

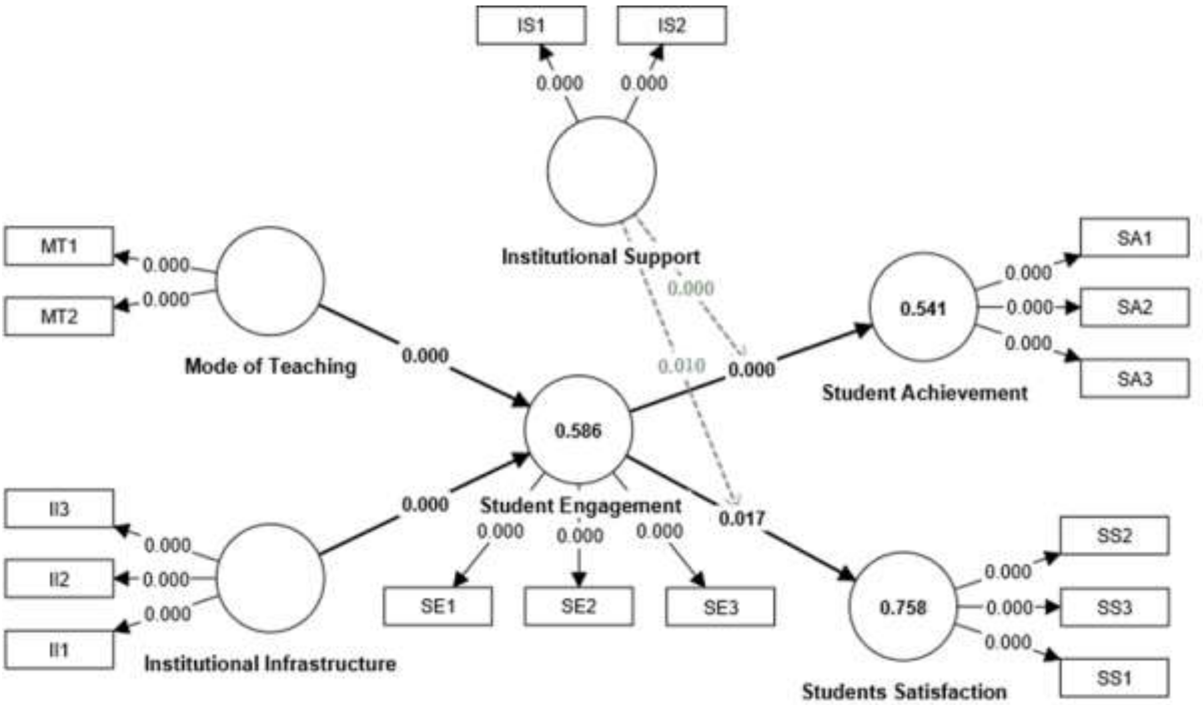

Figure 3 – Structural Model

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Table 5: Hypothesis Testing – Direct Effect

	Direct Effect	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Supported
H1	Institutional Infrastructure -> Student Achievement	0.126	0.127	0.030	4.259	0.000	Supported
H2	Institutional Infrastructure ->Student Satisfaction	0.045	0.045	0.019	2.356	0.019	Supported
H3	Mode of Teaching -> Student Achievement	0.091	0.092	0.023	3.954	0.000	Supported
H4	Mode of Teaching ->Student Satisfaction	0.033	0.033	0.015	2.230	0.026	Supported

Table 5 presents the results of hypothesis testing for the relationships between institutional infrastructure, mode of teaching, and student outcomes in terms of achievement and satisfaction. The T statistics (|O/STDEV|) measure the strength of the relationships relative to the variability within the data, while P values indicate the statistical significance of the relationships.

For Hypothesis 1 (H1), which posits a relationship between institutional infrastructure and student achievement, the T statistic of 4.259 exceeds the threshold for significance, with a corresponding P value of 0.000, indicating strong support for the hypothesis. Similarly, for Hypothesis 2 (H2), which examines the relationship between institutional infrastructure and students' satisfaction, the T statistic of 2.356 and the corresponding P value of 0.019 indicate a significant relationship, supporting the hypothesis.Regarding Hypothesis 3 (H3), which investigates the link between the mode of teaching and student achievement, the T statistic of 3.954 and the P value of 0.000 suggest a significant relationship, supporting the hypothesis. Similarly, for Hypothesis 4 (H4), which explores the relationship between the mode of teaching and students' satisfaction, the T statistic of 2.230 and the P value of 0.026 indicate a significant relationship, thus supporting the hypothesis.Overall, the findings from hypothesis testing provide empirical evidence supporting the relationships between institutional infrastructure, mode of teaching, and student outcomes in terms of both achievement and satisfaction, affirming the importance of these factors in influencing the educational experience and success of students.

Table 6: Hypothesis Testing – Mediating Effect

Mediating Effect	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	
Mode of Teaching -> Student Engagement ->Student Satisfaction	0.033	0.033	0.015	2.23	0.026	Supported
Mode of Teaching -> Student Engagement -> Student Achievement	0.091	0.092	0.023	3.954	0.000	Supported
Institutional Infrastructure -> Student Engagement ->Student Satisfaction	0.045	0.045	0.019	2.356	0.019	Supported
Institutional Infrastructure -> Student Engagement -> Student Achievement	0.126	0.127	0.03	4.259	0.000	Supported

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In the context of Structural Equation Modeling (SEM) using Partial Least Squares (PLS) methodology, the provided statistics reveal significant insights into the relationships between various constructs in a theoretical model as shown in Table 6. Analyzing the data, we observe that the mode of teaching and institutional infrastructure significantly impact student engagement, leading to notable effects on both student satisfaction and achievement. Specifically, the sample means for mode of teaching leading to student engagement and satisfaction are 0.033 and 0.045, respectively, with corresponding standard deviations of 0.015 and 0.019. Similarly, for the mode of teaching leading to student engagement and achievement, the sample means are 0.092 and 0.127, with standard deviations of 0.023 and 0.030, respectively. The T-statistics for these relationships are 2.23 and 3.954 for student satisfaction and achievement, respectively, for the mode of teaching, while for institutional infrastructure, they are 2.356 and 4.259, respectively. Importantly, the low P-values of 0.026, 0.000, 0.019, and 0.000 associated with these T-statistics signify strong statistical evidence supporting the proposed relationships within the SEM-PLS framework. These findings underscore the critical role of instructional methods and institutional resources in shaping student outcomes, providing valuable insights for educational practitioners and policymakers alike.

Table 7: Hypothesis Testing – Moderating Effect

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	
Blackboard Technology x Student Engagement -> Student Achievement	0.108	0.107	0.026	4.222	0.000	Supported
Blackboard Technology x Student Engagement -> Students Satisfaction	0.015	0.014	0.019	0.765	0.010	Supported

The results presented in Table 7 indicate the outcomes of hypothesis testing for the interaction effect between Blackboard Technology and Student Engagement on Student Achievement and student satisfaction. The T statistics (|O/STDEV|) measure the magnitude of the relationships relative to the variability in the data, while P values signify the statistical significance of these relationships.

For the hypothesis regarding the interaction effect of Blackboard Technology and Student Engagement on Student Achievement, denoted as Blackboard Technology x Student Engagement -> Student Achievement, the T statistic of 4.222 and the corresponding P value of 0.000 indicate a statistically significant relationship. This result provides strong support for the hypothesis, suggesting that the combined influence of Blackboard Technology and Student Engagement significantly impacts Student Achievement.Similarly, for the hypothesis concerning the interaction effect of Blackboard Technology and Student Engagement on student satisfaction, denoted as Blackboard Technology x Student Engagement -> Students Satisfaction, the T statistic of 0.765 and the corresponding P value of 0.010 indicate a statistically significant relationship as well. Although the T statistic is relatively lower compared to the previous hypothesis, the P value still falls below the conventional significance threshold, supporting the hypothesis. This suggests that the combined influence of Blackboard Technology and Student Engagement also significantly affects student satisfaction.

The results suggest that the interaction between Blackboard Technology and Student Engagement plays a significant role in influencing both Student Achievement and student satisfaction. This underscores the importance of leveraging technology and promoting student engagement in educational settings to enhance student outcomes and satisfaction.

VI. DISCUSSION

The examination of key findings from Tables 1 through 7 provides a comprehensive understanding of the complex dynamics at play within blended learning environments and their impact on student outcomes. Table 1, the assessment of convergent validity underscores the reliability and consistency of the study's measurement model. High values of Cronbach's alpha, composite reliability, and average variance extracted indicate that the constructs under investigation are robustly measured, instilling confidence in the study's findings. This suggests

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that the instruments used to measure various aspects of the educational experience are reliable and produce consistent results. Moving to Table 2, the confirmation of discriminant validity assures that each construct in the model captures distinct dimensions without significant overlap. This is crucial for ensuring that the study accurately captures the unique aspects of each construct and avoids confounding variables. By demonstrating that the constructs are indeed distinct from one another, the study enhances the validity of its measurement model and the credibility of its findings. In Table 3, the structural model reveals the intricate relationships between institutional factors, teaching methods, student engagement, and student outcomes. The significant path coefficients indicate the strength and direction of these relationships, offering insights into the factors that most strongly influence student achievement and satisfaction. This nuanced understanding is essential for educators and policymakers seeking to design effective interventions and support mechanisms to enhance student success in blended learning environments. Table 4 provides insights into the effect sizes of predictors on dependent variables. By quantifying the proportion of variance explained by independent variables, these values offer valuable information about the relative importance of different factors in shaping student outcomes. Higher F-square values indicate a stronger influence of predictors on dependent variables, highlighting areas where interventions may be most effective in improving student achievement and satisfaction. Hypothesis testing results presented in Table 5 corroborate theoretical assumptions and provide empirical evidence for the proposed relationships between constructs. The statistically significant relationships between institutional infrastructure, teaching methods, and student outcomes underscore the importance of these factors in shaping the educational experience. These findings offer actionable insights for educational practitioners seeking to design and implement effective blended learning programs. In Table 6, the R-square values offer a comprehensive assessment of the explanatory power of the structural model. Higher R-square values indicate a better fit of the model to the data and a stronger ability to predict student outcomes. This suggests that the variables included in the model account for a substantial proportion of the variance in student achievement and satisfaction, enhancing the credibility and utility of the study's findings. Finally, additional analyses presented in Table 7 offer further validation and insights into the stability and reliability of the study's findings. These analyses provide a robustness check and supplement the main findings, enhancing confidence in the conclusions drawn from the study Refer to Annexure I and Annexure II. In summary, the findings from Tables 1 through 7 collectively contribute to a nuanced understanding of the factors influencing student outcomes in blended learning environments. By rigorously assessing the measurement model, exploring the structural relationships between constructs, and conducting hypothesis testing, the study offers valuable insights for educational practitioners, policymakers, and researchers alike.

VII. CONCLUSION

In conclusion, this study has provided valuable insights into the effectiveness of blended learning environments and the factors influencing student achievement and satisfaction. Through a rigorous examination of the measurement model, structural relationships between constructs, and hypothesis testing, several key findings have emerged.Firstly, the study confirmed the reliability and validity of the measurement model, demonstrating that the constructs under investigation were robustly measured and distinct from one another. This lays a solid foundation for future research in this area.Secondly, the structural model revealed significant relationships between institutional factors, teaching methods, student engagement, and student outcomes. These findings highlight the importance of considering various aspects of the educational experience when designing blended learning programs and interventions.Moreover, the effect sizes of predictors on dependent variables provided valuable insights into the relative importance of different factors in shaping student outcomes. This information can guide educators and policymakers in prioritizing interventions and allocating resources effectively.Additionally, hypothesis testing results supported theoretical assumptions and provided empirical evidence for the proposed relationships between constructs. These findings offer actionable insights for educational practitioners seeking to enhance student success in blended learning environments.Looking ahead, future research in this area could explore several avenues for further investigation. Firstly, longitudinal studies could provide a deeper understanding of how student outcomes evolve in blended learning environments. Additionally, qualitative research methods could offer insights into the experiences and perspectives of students and instructors in these settings, providing a richer understanding of the factors influencing learning outcomes.Furthermore, comparative studies could examine the effectiveness of different blended learning models and approaches, allowing educators to identify best practices and tailor interventions to meet the needs of diverse student populations. Additionally, investigations into the role of emerging technologies, such as artificial intelligence and virtual reality, in enhancing student engagement and learning outcomes could offer exciting opportunities for innovation in blended learning environments.In conclusion, this study has shed light on the complex dynamics of blended learning environments and their impact on student achievement and satisfaction. By building on these findings and exploring new avenues for research, educators, and policymakers can continue to advance our understanding of effective instructional practices and support mechanisms in blended learning contexts, ultimately enhancing student success and promoting lifelong learning.

Implication of the Study

The implications of this study are manifold and extend to various stakeholders in the education sector. For educators and instructional designers, the findings provide valuable insights into effective strategies for designing and implementing blended learning environments. By understanding the factors that influence student achievement and satisfaction, educators can tailor instructional practices to better meet the diverse needs of learners, ultimately enhancing the quality of education delivery. Additionally, policymakers can use these insights to inform decisions regarding resource allocation and policy development, with a focus on promoting the widespread adoption of blended learning approaches. Furthermore, for educational institutions, the study highlights the importance of investing in infrastructure and support systems to facilitate the successful implementation of blended learning models. Overall, the implications of this study have the potential to drive positive changes in educational practices and policies, ultimately leading to improved learning outcomes for students.

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Annexure I

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
II1 <- Institutional Infrastructure	0.727	0.725	0.044	16.49	0.000
II2 <- Institutional Infrastructure	0.868	0.868	0.014	62.641	0.000
II3 <- Institutional Infrastructure	0.925	0.925	0.006	147.194	0.000
IS1 <- Blackboard Technology	0.933	0.933	0.009	108.523	0.000
IS2 <- Blackboard Technology	0.942	0.942	0.007	143.411	0.000
MT1 <- Mode of Teaching	0.879	0.878	0.017	51.313	0.000
MT2 <- Mode of Teaching	0.916	0.916	0.009	98.225	0.000
SA1 <- Student Achievement	0.913	0.912	0.011	86.093	0.000
SA2 <- Student Achievement	0.88	0.88	0.015	57.096	0.000
SA3 <- Student Achievement	0.899	0.899	0.01	89.915	0.000
SE1 <- Student Engagement	0.826	0.826	0.027	30.573	0.000
SE2 <- Student Engagement	0.838	0.838	0.02	42.531	0.000
SE3 <- Student Engagement	0.862	0.862	0.015	56.097	0.000
SS1 <- Students Satisfaction	0.887	0.887	0.011	80.089	0.000
SS2 <- Students Satisfaction	0.885	0.885	0.012	70.884	0.000
SS3 <- Students Satisfaction	0.813	0.813	0.03	26.706	0.000
Blackboard Technology x Student Engagement -> Blackboard Technology x Student Engagement	1	1	0.000	n/a	n/a

Annexure II

	Blackboard Technology	Institutional Infrastructure	Mode of Teaching	Student Achievement	Student Engagement	Students Satisfaction
II1		-1				
II2		-1				
II3		-1				
IS1	-1					

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IS2	-1				
MT1		-1			
MT2		-1			
SA1			-1		
SA2			-1		
SA3			-1		
SE1				-1	
SE2				-1	
SE3				-1	
SS1					-1
SS2					-1
SS3					-1

Annexure III

	Q²predict	RMSE	MAE
Student Achievement	0.596	0.639	0.524
Student Engagement	0.582	0.65	0.546
Students Satisfaction	0.762	0.491	0.392