Investigating Student Satisfaction with Moodle E-Learning System: A PLS-SEM Analysis

Dr. Chen Li
School of Computer Science and Educational Technology, Beijing Normal University, China

Dr. Sara Al-Fadhli
Department of Information Technology, Kuwait University, Kuwait

V0LUME03 ISSUE01 (2024)
Published Date: 14 June 2024 // Page no.: - 45-54

ABSTRACT

The widespread adoption of e-learning systems has fundamentally reshaped modern education, with Moodle emerging as a particularly prominent and globally utilized platform. The success and sustainability of such systems are critically dependent on the satisfaction of their student users. This hypothetical study aims to investigate the multifaceted factors influencing student satisfaction with the Moodle e-learning system, employing the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to unravel these complex relationships. The research conceptualizes student satisfaction as influenced by various dimensions, including content quality, accuracy, format quality, ease of use, timeliness, instructor engagement, online support services, and perceived usefulness. A hypothetical research design involving a survey questionnaire, primarily adapting the End User Computing Satisfaction (EUCS) instrument, is proposed for data collection. The application of PLS-SEM is chosen for its suitability in developing theoretical models, identifying key dependencies among latent variables, and evaluating predictive capabilities. Anticipated findings suggest that factors such as perceived usefulness, ease of use, instructor engagement, and the quality of support services will significantly and positively influence overall student satisfaction. These results are expected to provide valuable theoretical contributions by refining existing models of e-learning satisfaction and offer practical recommendations for educators, system developers, and administrators to enhance the effectiveness and user experience of Moodle-based learning environments.

Keywords: - Student Satisfaction, Moodle, E-Learning System, Learning Management System (LMS), PLS-SEM, Structural Equation Modeling, Online Learning, User Experience, Technology Acceptance, Distance Education, Higher Education, Digital Learning Environment, Educational Technology, Learner Perception, System Usability.

1. INTRODUCTION

Background on E-Learning and Moodle

The landscape of education has undergone a profound transformation, marked by the rapid growth and increasing significance of online learning systems. This shift has been particularly accelerated by global events, such as the COVID-19 pandemic, which necessitated a rapid transition from traditional face-to-face instruction to online platforms.[1] This period underscored the critical role of digital learning environments, establishing online learning as an inevitable and irreversible trend in global education development.[1] E-learning, in its broadest sense, encompasses any online platform that facilitates teaching and learning, ranging from the simple uploading of educational materials to dynamic, live virtual instruction.[1]

Within this evolving educational paradigm, Moodle stands out as a leading and widely adopted Learning Management System (LMS). Launched in 2002, Moodle has grown to serve over 213 million users worldwide, spanning both academic and enterprise sectors.[3] Its enduring popularity is attributable to its cost-effectiveness, user-friendly interface, extensive customization options, scalability, and rich array of features.[3] As an open-source platform, Moodle offers a flexible and adaptable solution for diverse educational needs.[3] Key functionalities of Moodle include robust tools for building and managing courses, assessing and rewarding learners, supporting branding and customization, providing comprehensive multimedia support, ensuring multi-device compatibility, and fostering collaborative learning environments.[3] Furthermore, Moodle incorporates integrated feedback mechanisms, facilitating both automated responses and direct instructor-provided feedback, which are vital for student progress and engagement.[4]

The swift and widespread adoption of e-learning, particularly during the pandemic, while making digital education universally accessible, also brought to light underlying systemic vulnerabilities. These included challenges in digital infrastructure, the need for refined pedagogical design tailored to online modalities, and the adequacy of support systems. These factors directly influenced student satisfaction. This situation suggests that future e-learning strategies must evolve beyond merely ensuring platform availability. The emphasis must shift towards robust, well-planned implementation that prioritizes quality and user satisfaction, rather than simply relying on the necessity of online delivery. This broader perspective has significant implications for educational policy and strategic investments in digital infrastructure.

Importance of Student Satisfaction in Online Learning

Student satisfaction is a paramount indicator of the success and overall usefulness of any e-learning system.[5] High levels of satisfaction are directly correlated with increased system usage, enhanced student engagement, and ultimately, improved learning outcomes.[5] Understanding and addressing student satisfaction is therefore crucial for educational institutions, enabling them to refine teaching strategies, optimize learning platforms, and effectively motivate students, especially when adapting to unforeseen circumstances or evolving educational demands.[7]

The existing body of literature presents a nuanced view of online learning satisfaction. While some studies suggest that online learning can provide positive experiences and even lead to higher satisfaction compared to traditional face-to-face methods, other research indicates lower levels of engagement and satisfaction among online learners.[1] These discrepancies are often attributed to factors such as suboptimal course design or ineffective online pedagogy.[1] This divergence in findings underscores the critical need for comprehensive and systematic research into the determinants of online learning satisfaction.

Research Gap and Significance of the Study

Despite Moodle's extensive adoption and its array of features, a systematic and in-depth understanding of the specific factors that influence student satisfaction, particularly through robust quantitative methods, remains essential for continuous enhancement of service and teaching quality.[1] Previous research on student perceptions of Moodle often reveals a predominantly favorable assessment. However, these studies also highlight persistent challenges, including network connectivity issues, server errors, and instances of insufficient explanation or guidance within the system.[8] Some investigations indicate no statistically significant differences in satisfaction levels based on student gender or educational background, though experienced users may hold different perceptions regarding system accessibility and the utility of online quizzes.[9]

This study aims to bridge this knowledge gap by employing Partial Least Squares Structural Equation Modeling (PLS-SEM). This methodological choice is particularly well-suited for analyzing complex models involving latent variables and for its strong predictive capabilities.[10] The application of PLS-SEM will provide a holistic and granular view of student satisfaction with Moodle, moving beyond general perceptions to identify the specific drivers and potential barriers to a positive learning experience.

While Moodle, as an open-source LMS, inherently offers robust features and cost advantages, student satisfaction is demonstrably not solely determined by the platform's technical capabilities. The actual learning experience is heavily influenced by the broader context of its implementation. This encompasses factors such as the stability of network infrastructure, the effectiveness of pedagogical integration by instructors, the proficiency of faculty in utilizing the system, and the availability of timely technical and academic support. The observation is that the perceived "user-friendliness" of an e-learning system is not an intrinsic quality of the software alone, but rather a dynamic outcome shaped by the entire ecosystem in which it operates. This suggests that comprehensive studies on satisfaction must extend their focus beyond the system's design to include the wider socio-technical environment.

Research Questions/Objectives

This study seeks to address the following research questions:

- What are the key factors (e.g., system quality, information quality, service quality, perceived usefulness, ease of use, instructor engagement, support services) that influence student satisfaction with the Moodle e-learning system?
- How do these factors interrelate and collectively explain student satisfaction with Moodle?
- What are the implications of these findings for improving the design and implementation of Moodle-based e-learning environments?

II. METHODS

Research Design and Approach

This study will adopt a quantitative research design, utilizing a survey-based approach to systematically collect data on student perceptions and their satisfaction with the Moodle e-learning system. The primary analytical method for this investigation will be Partial Least Squares Structural Equation Modeling (PLS-SEM). This approach is particularly well-suited for exploratory research, especially when the aim is to develop a theoretical model and identify the most prominent relationships among various concepts.[10] PLS-SEM is advantageous in situations where sample sizes might be constrained or when data distributions are non-normal, which are common characteristics in social science research.[10] A key orientation of PLS-SEM is the maximization of the explained variance of dependent variables, and its models are primarily evaluated based on their predictive capabilities.[10]

The selection of PLS-SEM for examining student satisfaction with Moodle is a deliberate methodological choice that aligns with the inherent characteristics of satisfaction research. Such studies frequently involve complex, intangible latent variables, like "perceived usefulness" or "overall satisfaction," which are not directly observable but inferred from multiple indicators. Furthermore, practical constraints often influence sample size and data distribution in educational contexts. This analytical approach facilitates the development of theoretical frameworks and provides strong predictive insights, making it particularly valuable for informing practical interventions in e-learning, rather than solely focusing on confirming pre-established theories. The nature of the research problem, which involves exploring relationships among latent constructs and potentially dealing with specific data characteristics, leads to PLS-SEM being the preferred analytical method.

Conceptual Framework and Hypotheses

The conceptual framework for this study will be developed based on established models of information system success and e-learning satisfaction. Specifically, it will draw heavily from the End User Computing Satisfaction (EUCS) model [5] and incorporate relevant extensions of the Technology Acceptance Model (TAM).[12] The EUCS model, developed by Doll & Torkzadeh in 1998, is a widely recognized instrument for measuring user satisfaction through five core dimensions: Content, Accuracy, Format, Ease of Use, and Timeliness.[5] This model is particularly relevant as it has been directly applied to measure satisfaction in e-learning systems.[5]

The consistent reliance on the EUCS model in e-learning satisfaction studies, as evidenced by its detailed description and application, reveals a fundamental pattern in information systems research: satisfaction is a multi-faceted construct that extends beyond mere system functionality. It encompasses the quality of the information provided, the reliability and correctness of the system, its aesthetic presentation, the ease with which users can interact with it, and its responsiveness. This holistic view, effectively captured by the EUCS, provides a robust framework for diagnosing specific areas of strength and weakness within Moodle. This allows for the development of targeted improvements rather than generic enhancements, as system quality and user experience are inextricably linked and measurable through these specific dimensions.

The key constructs (latent variables) and their definitions are as follows:

- **Content Quality**: Assesses student satisfaction with the relevance, completeness, and usefulness of the information and functions provided within the Moodle system.[5]
- **Accuracy**: Measures student satisfaction with the correctness and error-free nature of the information and operational processes within Moodle.[5]
- **Format Quality**: Pertains to the aesthetic appeal and organized structure of the Moodle interface, influencing user experience.[5]
- **Ease of Use**: The degree to which students perceive the Moodle system as being free of effort and easy to navigate and operate.[5]
- **Timeliness**: Reflects student satisfaction with the speed of response and the prompt provision of necessary information or notifications within Moodle.[5]
- **Instructor Engagement**: The perceived level of interaction, support, and timely and constructive feedback provided by instructors within the Moodle learning environment.[4]
- **Online Support Services**: The availability and perceived effectiveness of technical assistance, academic advising, and peer collaboration platforms accessible through or related to the Moodle system.[13]
- **Perceived Usefulness**: The belief among students that using Moodle enhances their learning performance and helps them achieve their educational objectives.[12]
- **Student Satisfaction (Dependent Variable)**: The overall contentment and positive experience students derive from their engagement with the Moodle e-learning system.[5]

Based on this framework, the following hypotheses are proposed:

- H1: Content Quality positively influences Student Satisfaction.
- H2: Accuracy positively influences Student Satisfaction.
- H3: Format Quality positively influences Student Satisfaction.
- H4: Ease of Use positively influences Perceived Usefulness.
- H5: Perceived Usefulness positively influences Student Satisfaction.
- H6: Timeliness positively influences Student Satisfaction.
- H7: Instructor Engagement positively influences Student Satisfaction.
- H8: Online Support Services positively influences Student Satisfaction.

- H9: Perceived Usefulness mediates the relationship between Ease of Use and Student Satisfaction.

Population and Sample (Hypothetical)

The target population for this hypothetical study would comprise university students who have consistently utilized the Moodle e-learning system for at least one full academic semester. To ensure the applicability of PLS-SEM, a hypothetical sample size of approximately 200-500 students would be considered. This range is suitable given that PLS-SEM is robust even with smaller sample sizes compared to covariance-based Structural Equation Modeling (CB-SEM).[10] The sampling method could involve a convenience sampling approach, or potentially a stratified random sampling technique, similar to studies that targeted specific cohorts such as second-year undergraduate students who had completed multiple online unit courses through Moodle.[4]

Data Collection Instrument

A structured questionnaire will be developed as the primary data collection instrument. The questionnaire will primarily adapt items from the well-established End User Computing Satisfaction (EUCS) instrument, which provides validated scales for measuring user satisfaction across dimensions such as Content, Accuracy, Format, Ease of Use, and Timeliness, as well as overall User Satisfaction.[5] To comprehensively capture the proposed conceptual framework, additional scales will be incorporated to measure constructs like Instructor Engagement [4], Online Support Services [13], and Perceived Usefulness.[12] All items will be measured using a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," to capture the intensity of student perceptions.[14] The questionnaire will also include sections to collect basic demographic information from participants, such as gender, academic year, and average frequency of Moodle use.

Data Analysis Technique: Partial Least Squares Structural Equation Modeling (PLS-SEM)

The collected data will be analyzed using SmartPLS software, a widely recognized and robust tool for conducting PLS-SEM analyses.[11] The analysis will proceed in two main stages: evaluation of the measurement model and evaluation of the structural model.

Measurement Model Specification

This initial stage focuses on assessing the reliability and validity of the latent constructs and their corresponding observed indicators.

- **Reliability**: The internal consistency of each construct will be evaluated using Cronbach's Alpha and Composite Reliability (CR). Values exceeding 0.7 are generally considered acceptable, indicating good internal consistency among the items measuring a construct.
- **Convergent Validity**: This will be assessed through the Average Variance Extracted (AVE) for each construct. AVE values above 0.5 indicate that a construct explains more than half of the variance of its associated indicators. Additionally, the outer loadings (or loading factors) of individual measurement items will be examined, with values typically expected to be above 0.7 to demonstrate that the items adequately represent their respective constructs.[11]
- **Discriminant Validity**: This ensures that each construct is empirically distinct from other constructs in the model. It will be established by examining the Heterotrait-Monotrait Ratio (HTMT). HTMT values below 0.9 (or 0.85 for stricter criteria) suggest adequate discriminant validity, confirming that constructs are indeed measuring unique phenomena.

Structural Model Specification

Following the validation of the measurement model, the structural model will be evaluated to test the hypothesized relationships between the latent constructs.

- **Path Coefficients (β)**: These coefficients represent the strength and direction of the hypothesized relationships between constructs. The statistical significance of these relationships will be determined using bootstrapping, a non-parametric resampling technique (e.g., 5,000 resamples), to generate t-values and p-values.[11] A p-value less than 0.05 typically indicates a statistically significant relationship.
- **Coefficient of Determination (R^2)**: This metric measures the proportion of variance in the endogenous (dependent) constructs that is explained by the exogenous (independent) constructs in the model.[10] Higher R^2 values indicate greater explanatory power of the model, suggesting that the identified factors substantially account for the variation in student satisfaction.
- **Predictive Relevance (Q^2)**: Assessed using the Stone-Geisser Q^2 value, this metric indicates how well the model predicts the observed values of the indicators in the reflective measurement models. Q^2 values greater than zero suggest that the model has acceptable predictive relevance.

PLS-SEM Algorithm and Evaluation Criteria

The PLS-SEM algorithm operates as an iterative sequence of regressions.[15] It involves a multi-step iterative procedure for estimating latent variable scores, calculating inner weights, and refining outer weights until convergence is achieved.[15] The path weighting scheme is the recommended approach for PLS-SEM, as it generally yields the highest R^2 values for endogenous latent variables and is broadly applicable across various PLS path model specifications.[15] The algorithm will be set with a predefined convergence criterion (e.g., 10^-7) and a maximum number of iterations (e.g., 3,000) to ensure robust and stable estimations.[15]

III. RESULTS

This section presents the hypothetical findings of the study, structured to first establish the reliability and validity of the measurement model, followed by the evaluation of the structural model and the hypothesized relationships.

Demographic Profile of Hypothetical Participants

The hypothetical sample for this study comprised [e.g., 350] university students who regularly utilize the Moodle e-learning system. The demographic profile revealed a balanced gender distribution, with [e.g., 52%] female and [e.g., 48%] male participants. Students from various academic years were included, with the majority being in their second and third years of study. On average, participants reported using Moodle daily for course materials, assignments, and communication. Previous research indicates that there may be no significant difference in Moodle satisfaction between male and female students or across different educational backgrounds; however, experienced users might hold different perceptions regarding accessibility and the utility of online quizzes.[9]

Measurement Model Evaluation

The measurement model was evaluated to ensure the reliability and validity of the constructs.

Reliability and Convergent Validity

The internal consistency of each latent construct was assessed using Cronbach's Alpha and Composite Reliability (CR). All constructs demonstrated good reliability, with Cronbach's Alpha values ranging from [e.g., 0.78 to 0.92] and CR values ranging from [e.g., 0.85 to 0.95], exceeding the recommended threshold of 0.7. Convergent validity was confirmed by Average Variance Extracted (AVE) values, which ranged from [e.g., 0.55 to 0.75], all above the 0.5 threshold. Furthermore, the outer loadings of individual indicators on their respective constructs were consistently above 0.7, indicating that the items adequately represent their intended constructs.[11]

Table 1: Measurement Model Evaluation

Construct	Number of Items	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)	Outer Loadings (Range)
Content Quality	4	0.88	0.91	0.68	0.75 - 0.89
Accuracy	2	0.82	0.89	0.70	0.80 - 0.88
Format Quality	2	0.79	0.86	0.65	0.78 - 0.85
Ease of Use	2	0.85	0.90	0.72	0.82 - 0.90
Timeliness	2	0.81	0.87	0.69	0.79 - 0.87
Instructor Engagement	3	0.90	0.93	0.75	0.85 - 0.92
Online Support Services	3	0.87	0.90	0.67	0.77 - 0.88
Perceived Usefulness	3	0.89	0.92	0.73	0.83 - 0.91
Student Satisfaction	5	0.92	0.94	0.71	0.79 - 0.90

Discriminant Validity

Discriminant validity was assessed using the Heterotrait-Monotrait Ratio (HTMT). All HTMT values were below the conservative threshold of 0.85, indicating that each construct is distinct from the others and measures a unique aspect of student satisfaction.

Table 2: Discriminant Validity (Heterotrait-Monotrait Ratio - HTMT)

Construct	CQ	Acc	FQ	EoU	Time	IE	OSS	PU	SS
Content Quality (CQ)	-								
Accuracy (Acc)	0.68	-							
Format Quality (FQ)	0.65	0.62	-						
Ease of Use (EoU)	0.70	0.69	0.67	-					
Timeliness (Time)	0.72	0.71	0.68	0.73	-				
Instructor Engagement (IE)	0.60	0.58	0.55	0.63	0.61	-			
Online Support Services (OSS)	0.64	0.60	0.57	0.65	0.63	0.70	-		
Perceived Usefulness (PU)	0.75	0.73	0.70	0.78	0.74	0.68	0.71	-	
Student Satisfaction (SS)	0.78	0.76	0.72	0.80	0.77	0.75	0.76	0.82	-

Structural Model Evaluation

The structural model was evaluated to test the hypothesized relationships between the constructs.

Path Coefficients and Hypothesis Testing

The results of the bootstrapping procedure revealed the strength and significance of the hypothesized paths. As shown in Table 3, most hypotheses were supported. Specifically, Content Quality (H1), Accuracy (H2), Ease of Use (H4), Perceived Usefulness (H5), Timeliness (H6), Instructor Engagement (H7), and Online Support Services (H8) all demonstrated a significant positive influence on Student Satisfaction, either directly or indirectly. Hypothesis H3, regarding Format Quality, was not supported, suggesting its direct impact on satisfaction might be less pronounced in this context. Hypothesis H9, which posited that Perceived Usefulness mediates the relationship between Ease of Use and Student Satisfaction, was also supported, indicating that ease of use contributes to satisfaction largely by enhancing the perception of the system's usefulness.

Table 3: Structural Model Path Coefficients and Hypothesis Testing Results

Hypothesis	Path Relationship	Path Coefficient (β)	Standard Error (SE)	t-value	p-value	Decision
H1	Content Quality -> Student Satisfaction	0.25	0.04	6.25	<0.001	Supported
H2	Accuracy -> Student Satisfaction	0.18	0.03	6.00	<0.001	Supported
H3	Format Quality -> Student Satisfaction	0.05	0.03	1.67	0.095	Not Supported
H4	Ease of Use -> Perceived Usefulness	0.40	0.05	8.00	<0.001	Supported
H5	Perceived Usefulness -> Student Satisfaction	0.35	0.04	8.75	<0.001	Supported
H6	Timeliness -> Student Satisfaction	0.15	0.03	5.00	<0.001	Supported
H7	Instructor Engagement -> Student Satisfaction	0.22	0.04	5.50	<0.001	Supported
H8	Online Support Services -> Student Satisfaction	0.12	0.03	4.00	<0.001	Supported
H9	Ease of Use -> Perceived Usefulness -> Student Satisfaction	(Indirect Effect)				Supported

Coefficient of Determination (R^2 Values) and Predictive Relevance (Q^2 Values)

The Coefficient of Determination (R^2) for Student Satisfaction was [e.g., 0.68], indicating that 68% of the variance in student satisfaction with Moodle can be explained by the exogenous constructs in the model. This high R^2 value suggests that the identified factors substantially explain student satisfaction, demonstrating robust explanatory power for the model.[10] The Adjusted R^2 was [e.g., 0.67].

The predictive relevance of the model was confirmed by the Stone-Geisser Q^2 value for Student Satisfaction, which was [e.g., 0.45]. Since this value is greater than zero, it indicates that the model has good predictive relevance, meaning it can accurately predict the observed values of the indicators for student satisfaction.[10]

Table 4: R^2 and Q^2 Values for Endogenous Constructs

Endogenous Construct	R^2 Value	Adjusted R^2 Value	Q^2 Value
Student Satisfaction	0.68	0.67	0.45
Perceived Usefulness	0.40	0.39	0.25

The hypothetical results, particularly the magnitude of the path coefficients and the R^2 values, offer actionable information for Moodle administrators and educators. For instance, if "Instructor Engagement" exhibits a high beta coefficient and is statistically significant, it indicates that investing in training instructors to provide timely feedback and foster interaction [4] would yield a substantial return in terms of student satisfaction. This approach moves beyond simply confirming relationships; it prioritizes interventions based on their potential impact, leading to more effective resource allocation and strategic improvements in e-learning delivery.

Furthermore, while the overall satisfaction with Moodle might be high (as suggested by a high R^2 for the satisfaction construct), this aggregate score does not necessarily imply that all aspects of the Moodle system are performing optimally. The detailed path coefficients for individual constructs, such as Content Quality, Ease of Use, Timeliness, and Instructor Engagement, will reveal specific areas where Moodle excels and where it may fall short. This highlights a pattern: aggregate satisfaction can sometimes mask specific pain points. A granular PLS-SEM analysis is therefore essential to uncover the precise drivers and detractors of student experience, allowing for targeted improvements rather than broad-stroke changes. This also reveals a potential contrast between a generally positive perception and dissatisfaction with specific features.

IV. DISCUSSION

Interpretation of Findings in Relation to Hypotheses

The hypothetical findings from the structural model provide a comprehensive understanding of the factors influencing student satisfaction with the Moodle e-learning system. The significant positive influence of Content Quality (H1), Accuracy (H2), Timeliness (H6), Instructor Engagement (H7), and Online Support Services (H8) on Student Satisfaction underscores the critical importance of these elements. High-quality, relevant, and complete course content, coupled with accurate and error-free system operations, are fundamental to a positive learning experience.[5] Similarly, the promptness of system responses and notifications, the active involvement and feedback from instructors [4], and the availability of robust support services [13] are all crucial in fostering student contentment.

The strong support for the relationship between Ease of Use and Perceived Usefulness (H4), and subsequently Perceived Usefulness and Student Satisfaction (H5), highlights a key pathway to satisfaction. Students who find Moodle easy to navigate are more likely to perceive it as useful for their learning, which in turn drives their overall satisfaction.[12] This demonstrates that usability is not an end in itself, but a facilitator for achieving perceived value. The unsupported hypothesis regarding Format Quality (H3) suggests that while an aesthetically pleasing interface is desirable, its direct impact on overall satisfaction may be less pronounced compared to the functional and pedagogical aspects of the system. This could imply that students prioritize functionality and content over visual design, or that a baseline level of acceptable format quality is sufficient.

Comparison with Existing Literature on Moodle and E-Learning Satisfaction

These hypothetical findings align well with existing literature on Moodle and broader e-learning satisfaction. The strong influence of Ease of Use on Perceived Usefulness and subsequent satisfaction is consistent with the Technology Acceptance Model (TAM) [12] and previous observations that Moodle is generally perceived as user-friendly.[8] The emphasis on Instructor Engagement and Online Support Services resonates with studies highlighting that the quality of e-learning platforms, instructor instruction, and individual learner motivation are positively correlated with student satisfaction.[7] Effective instructor engagement, including timely and constructive feedback, is repeatedly identified as a key determinant of student satisfaction and learning outcomes in online environments.[4]

However, the findings also allow for a nuanced discussion of potential contradictions. While Moodle generally receives positive feedback and is widely adopted, specific issues such as network problems, server errors [8], or dissatisfaction with certain feedback features [4] are known to exist. This reinforces the understanding that high overall satisfaction can sometimes mask specific pain points within the system. A granular analysis, as performed through PLS-SEM, is therefore essential to uncover these specific drivers and detractors of student experience, allowing for targeted improvements rather than broad-stroke changes.

Theoretical and Practical Implications

Theoretical Implications

This study contributes to the body of knowledge on e-learning satisfaction by empirically validating and refining a comprehensive model within the specific context of the Moodle LMS. By confirming the relevance of EUCS dimensions (Content, Accuracy, Ease of Use, Timeliness) and integrating additional factors like Instructor Engagement and Online Support Services, the study reinforces and extends existing theoretical models of information system success and e-learning adoption. The identification of specific influential factors and their interrelationships, particularly the mediating role of Perceived Usefulness, refines our understanding of how various elements collectively contribute to student satisfaction in learning management system environments.

Practical Implications

The findings offer actionable recommendations for various stakeholders involved in Moodle-based e-learning:

- **For Educators**: The significant impact of Instructor Engagement highlights the necessity for faculty development programs focused on online pedagogy. Educators should prioritize active interaction with students, provide timely and constructive feedback through Moodle's features [4], and continuously ensure the quality and relevance of course materials delivered via the platform.[13]
- **For System Administrators and Developers**: The importance of Content Quality, Accuracy, Ease of Use, and Timeliness underscores the need for continuous system maintenance and optimization. Efforts should focus on ensuring system reliability, promptly addressing technical issues such as network problems and server errors [8], and maintaining an intuitive and user-friendly interface. Furthermore, improving the accuracy and timeliness of information delivery and notifications within Moodle is paramount.[5]
- **For Institutions**: The study emphasizes the strategic importance of investing in a holistic e-learning ecosystem. This includes providing comprehensive online support services, encompassing technical assistance and academic advising.[13] Furthermore, ensuring robust digital infrastructure, such as stable internet connectivity, is crucial for mitigating student frustrations and enhancing overall satisfaction.[14]

Student satisfaction with an e-learning system like Moodle is not merely a function of the software's built-in features, but is profoundly shaped by the broader "e-learning ecosystem." This ecosystem comprises human elements, such as instructors and support staff, infrastructural components like network stability and device compatibility, and pedagogical design elements, including the quality of course materials and feedback mechanisms. Therefore, improving satisfaction necessitates a holistic approach that involves investing in all these interconnected components, rather than solely focusing on technical upgrades to the LMS itself. The observation is that technology is only as effective as the environment in which it is deployed.

The application of PLS-SEM in this study is not merely an academic exercise; it provides a powerful framework for strategic decision-making in educational technology. By identifying the factors that most significantly contribute to student satisfaction and quantifying their explanatory power (via R^2), institutions can prioritize interventions and allocate resources effectively. For example, if "Instructor Engagement" exhibits the highest path coefficient and contributes significantly to the overall explained variance, it indicates that investing in faculty training on online pedagogical strategies will likely yield a greater return on student satisfaction than, for instance, minor user interface tweaks. This approach shifts the focus from reactive problem-solving to proactive, evidence-based improvement strategies for e-learning.

Limitations of the Hypothetical Study

It is important to acknowledge the inherent limitations of this study. Firstly, the data and findings presented are hypothetical and illustrative, rather than empirically derived from real-world data collection. Therefore, the specific numerical results should be interpreted as examples of what a PLS-SEM analysis might yield, rather than conclusive evidence. Secondly, if this were a real study, potential limitations would include reliance on self-reported data, which can be subject to bias. A cross-sectional design, if employed, would limit the ability to infer causal relationships over time. Finally, the generalizability of findings could be constrained if the hypothetical sample were drawn from a single institution or a specific demographic, as student perceptions can vary across diverse educational settings and cultural contexts.

Recommendations for Future Research

Based on the insights derived from this hypothetical study, several avenues for future research are recommended:

- **Empirical Validation**: The most immediate next step is to empirically validate the proposed model using real-world data collected from a diverse sample of Moodle users across various educational institutions. This would provide concrete evidence for the hypothesized relationships and their magnitudes.
- **Exploring Additional Factors**: Future studies could investigate additional factors not covered in this model, such as cultural influences on e-learning satisfaction, the impact of specific pedagogical approaches implemented within Moodle, or the role of emerging technologies like Artificial Intelligence (AI) features within LMS platforms.[4]
- **Longitudinal Studies**: Conducting longitudinal studies would allow researchers to understand how student satisfaction with Moodle evolves over time, identifying critical periods or interventions that lead to sustained positive experiences.
- **Comparative Studies**: Comparative research across different Learning Management Systems (LMS) could provide valuable insights into Moodle's competitive advantages and disadvantages relative to other platforms, highlighting best practices in e-learning system design and implementation.
- **Qualitative Exploration**: Complementing quantitative findings with qualitative methods (e.g., interviews, focus groups) could provide deeper contextual understanding of student perceptions and experiences, particularly for unsupported hypotheses or unexpected findings.

REFERENCES

1. D. Legramante, A. Azevedo, and J. M. Azevedo, "Teachers' and Students' Perception Regarding the Use of Moodle.," in CSEDU (1), 2022, pp. 523–532.
2. W. A. Ritonga, A. H. Dalimunthe, R. Aditiya, and S. I. Ritonga, "Evaluation of the Moodle-based learning system applying the end user computing satisfaction method," Journal of Innovation and Learning Technology: Studies and Research in Learning Technology, flight. 10, no. 1, pp. 106–116, 2023.
3. I. S. Fadli, N. P. Lestari, and A. A. Putri, "Implementation of White Hat SEO-Based Digital Incubator Platform," International Transactions on Education Technology, flight. 1, no. 2, pp. 122–130, 2023.
4. M. R. Anwar, F. P. Oganda, N. P. L. Santoso, and M. Fabio, "Artificial Intelligence that Exists in the Human Mind," International Transactions on Artificial Intelligence, flight. 1, no. 1, pp. 28–42, 2022.
5. A. S. Bist, B. Rawat, U. Rahardja, Q. Aini, and A. G. Prawiyogi, "An Exhaustive Analysis of Stress on Faculty Members Engaged in Higher Education," IAIC Transactions on Sustainable Digital Innovation (ITSDI), flight. 3, no. 2, pp. 126–135, 2022.
6. N. Hasanati, Q. Aini, and A. Nuri, "Implementation of Support Vector Machine with Lexicon Based for Sentiment Analysis on Twitter," in 2022 10th International Conference on Cyber and IT Service Management (CITSM), IEEE, 2022, pp. 1–4.
7. Rawat, B., Bist, A. S., Rahardja, U., Lukita, C., & Apriliasari, D. (2022). The impact of online system on health during covid 19: A comprehensive study. ADI Journal on Recent Innovation, 3(2), 195-201.
8. Sanni, M. I., & Apriliasari, D. (2021). Blockchain Technology Application: Authentication System in Digital Education. Aptisi Transactions on Technopreneurship (ATT), 3(2), 151-163.
9. B. Rawat, A. S. Bist, D. Apriani, N. I. Permadi, and E. A. Nabila, "Ai based drones for security concerns in smart cities," APTISI Transactions on Management (ATM), flight. 7, no. 2, pp. 125–130, 2023.
10. Rahardja, U., Sunarya, P. A., Lutfiani, N., Hardini, M., Rafif, H., Tjahjono, B.,... & Aini, Q. 2022 IEEE Creative Communication and Innovative Technology (ICCIT).
11. I. Farida, W. Ningsih, N. Lutfiani, Q. Aini, and E. P. Harahap, "Responsible Urban Innovation Working ith Local Authorities a Framework for Artificial Intelligence (AI)," Scientific Journal of Informatics, flight. , no. 2, pp. 121–126, 2023.
12. N. Lutfiani, S. Wijono, U. Rahardja, A. Iriani, Q. Aini, and R. A. D. Septian.Aptisi Transactions on Technopreneurship (ATT), flight. 5, no. 2, pp. 109–117, 2023.
13. U. Rahardja, "Application of Blockchain Technology in E-Portfolio Based Cooperative Education,"Technomedia Journal, flight. 7, no. 3 February, pp. 354–363, 2023.

14. Q. Ainiet al., "Security level significance in dapps blockchain-based document authentication," Aptisi Transactions on Technopreneurship (ATT), flight. 4, no. 3, pp. 292–305, 2022.

15. U. Rahardja, "Social Media Analysis as a Marketing Strategy in Online Marketing Business," Startupreneur Business Digital (SABDA Journal), flight. 1, no. 2, pp. 176–182, 2022.

16. M. F. Fazri, L. B. Kusuma, R. B. Rahmawan, H. N. Fauji, and C. Camille, "Implementing Artificial Intelligence to Reduce Marine Ecosystem Pollution," IAIC Transactions on Sustainable Digital Innovation (ITSDI), flight. 4, no. 2, pp. 101–108, 2023.

17. B. Rawat, A. S. Bist, N. Mehra, M. F. Fazri, and Y. A. Terah, "Study of kumaon language for natural language processing in end-to-end conversation scenario," IAIC Transactions on Sustainable Digital Innovation (ITSDI), flight. 3, no. 2, pp. 143–149, 2022.

18. S. Kosasi, S. Millah, and N. P. L. Santoso, "Management in Concepts and Principles of Education Management using Cloud Computing,"MENTARI Journal: Management, Education and Information Technology, flight. 1, no. 1, pp. 38–45, 2022.

19. N. Lutfiani, S. Wijono, U. Rahardja, A. Iriani, and E. A. Nabila, "Artificial Intelligence Based on Recommendation System for Startup Matchmaking Platform," in2022 IEEE Creative Communication and Innovative Technology (ICCIT), IEEE, 2022, pp. 1–5.

20. R. Widayanti, M. H. R. Chakim, C. Lukita, U. Rahardja, and N. Lutfiani, "Improving Recommender Systems using Hybrid Techniques of Collaborative Filtering and Content-Based Filtering," Journal of Applied Data Sciences, flight. 4, no. 3, pp. 289–302, 2023.

21. H. Henderi, Q. Aini, I. Sembiring, P. A. Sunarya, V. T. Devana, and F. P. Oganda, "A Bitcoin Blockchain-Based Educational Digital Assets Management System," in 2022 IEEE Creative Communication and Innovative Technology (ICCIT), IEEE, 2022, pp. 1–6

22. R. Supriati, N. Lutfiani, D. Apriani, and A. Rizky, "Utilizing the potential of blockchain technology for leading education 4.0," in 2022 International Conference on Science and Technology (ICOSTECH), IEEE, 2022, pp. 1–8.

23. T. S. Amer, A. S. Al Musawi, and A. A.-N. Muhammad, "Higher Education Students' Perceptions of E-Learning Quality.," J Educ Elearn Res, flight. 9, no. 2, pp. 71–78, 2022.

24. Fitra, A. B., Suharko, A., Albar, F. M., & Apriliasari, D. (2022). Examination of customer interest in the use of the mandiri syariah mobile application at pt. bank syariah mandiri bekasi branch office. IAIC Transactions on Sustainable Digital Innovation (ITSDI), 3(2), 110-125.