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Predicting personalized mathematics learning among pre-university students in the Maldives

Mausooma Mohamed[1,2], Ahmad Fauzi Mohd Ayub[3], Maizura Yasin[4], Nur Raihan Che Nawi[5]
[1]Institute for Mathematical Research, Universiti Putra Malaysia, Serdang, Malaysia
[2]Centre for Foundation Studies, The Maldives National University, Malé, Maldives
[3]Department of Foundation of Education, Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia
[4]Department of Language and Humanities Education, Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia
[5]Department of Professional Development and Continuing Education, Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia

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ABSTRACT

The use of learning management systems (LMS), such as Moodle, for personalized mathematics learning (PML) is successful; nonetheless, its performance depends on several factors. This study investigates the factors influencing the utilization of LMS for PML at the Maldives National University (MNU). A correlational study was conducted involving 120 randomly selected pre-university students using an online questionnaire to measure performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and student commitment (SC) toward LMS usage behavior (UB). Data analysis with IBM statistical package for the social sciences (SPSS) statistics version 25.0 revealed significant positive relationships between LMS UB and PE (r=0.624**), EE (r=0.644**), FC (r=0.533**), and SC (r=0.696**), with SC being the strongest predictor. SI showed a weaker positive relationship (r=0.204). The study also discovered a multiple correlation (R) value of 0.807 and an analysis of variance (ANOVA) (F (5, 114)=42.497, p=0.000). The study's findings underscore the significance of these factors in promoting LMS adoption and effective use concluding that focusing on these key predictors can enhance PML and improve student engagement and performance.

Corresponding Author:

Mausooma Mohamed
Institute for Mathematical Research, Universiti Putra Malaysia
Lorong Tulang Daing 1, Serdang, Selangor, Malaysia
Email: mausooma.mohamed@mnu.edu.mv

1. INTRODUCTION

Mathematics is crucial in higher education, especially in engineering and science. Transitioning from secondary to university-level mathematics can be challenging due to differences in teaching approaches, prior knowledge, and attitudes [1]–[3]. Developing higher-order thinking skills, such as problem-solving, is vital in secondary education to prepare students for advanced concepts [4], [5]. Incorporating technology in mathematics education presents pedagogical and technological challenges in digitalizing schools [6] and higher education [7].

Personalized instructional techniques integrated into learning management systems (LMS) like Moodle are emerging as a new approach in higher education in the Maldives. E-learning has transformed education by changing how students interact with materials and teachers, which is crucial in distance education, particularly in remote island communities. Open and distance learning support systems improve timely feedback and overall support for island students [8]. Personalized methods for mathematics e-learning

have emerged as strategies to overcome educational issues and improve learning experiences. This involves leveraging tools like Moodle to customize learning paths based on individual needs. Integration of formative assessments on platforms like Moodle has greatly enhanced the self-regulatory learning skills of blended learning students at the Maldives National University (MNU) [9].

The utilization of personalized mathematics learning (PML) through LMS among pre-university students in the Maldives can be predicted based on various factors. Customized teaching paths in mathematics education using platforms like Moodle can overcome obstacles and enhance learning. For example, research by Mohamed [9] examined the relationship between self-regulatory skills and Moodle formative assessment practices, finding that regular formative assessments on Moodle improved these skills. Other research [10] compared e-learning adoption between massive open online course (MOOC) and LMS in pre-calculus, revealing a preference for MOOC due to perceived resource impact. Sáiz-Manzanares *et al.* [11] investigated a personalized e-learning system based on Moodle and found it predicted learning outcomes by 42.3% and effective behavior patterns by 74.2%, while also increasing student satisfaction. MOOC via LMS supports meaningful learning and continued LMS usage in other subjects [12], [13].

Personalized mathematics learning via LMS is crucial for integrating factors influencing student performance [14]. Adaptive, personalized online courses in mathematics enhance learning by identifying risk groups and offering self-tutoring programs [15]. Personalized learning (PL) tailors' experiences to students' needs, interests, and strengths, promoting engagement and alternative means of expression [16]. In K-12 schools, key elements such as competency-based progress, criterion-referenced assessment, and project-based learning significantly influence student commitment (SC) and performance [17]. Insights from LMS in mathematics classes show advantages like feasible learning tools and knowledge acquisition, but challenges include unpredictable occurrences and internet disruptions [18]. These findings emphasize the importance of personalized approaches and LMS usage behavior (UB) in enhancing SC and performance in mathematics, urging curriculum developers to incorporate these approaches.

Cakir [19] developed an instructional management system adaptable to individual students, incorporating personalized adaptive teaching and test materials. This system provides learning materials based on prior knowledge levels and creates special courses by adapting content to the student's level. Study by Desai *et al.* [20] showcased the successful application of innovative teaching-learning evaluation (TLE) techniques in mathematics education using the K. J. Somaiya College of Engineering-LMS (KJSCE-LMS) in both online and blended learning environments. Their findings suggest that the systematic use of KJSCE-LMS facilitates easier, more effective, and meaningful mathematics learning. Nearly 98% of the students reported that the LMS content significantly aided their understanding of concepts, leading to the conclusion that LMS tools can enhance the learning process, motivate students, improve academic outcomes, and have a positive impact on student development.

In a separate study, Ogwari *et al.* [21] investigated the influence of PL on the mathematics performance of secondary school students in Awendo Sub-County, Kenya. Their results indicated that the experimental group, which implemented PL, achieved a higher performance index than the control group. Moreover, the study found no significant difference in post-test scores between male and female students, suggesting that PL has an equal impact on achievement across genders. The findings underscore the positive effects of properly implemented PL practices on student success in mathematics, emphasizing the need for adequate resources, manpower, time, and effective methodologies.

Students face difficulties related to insufficient proficiency, receptivity, and limited time when incorporating LMS into the educational process [22], [23]. Challenges include a decline in enthusiasm for technology in instructional practices, insufficient training, and inadequacies in skill acquisition for managing and integrating technological tools [24], [25]. This raises questions about utilizing LMS on the Moodle platform and its application by educators in the Maldivian educational framework.

With unique geographical challenges, the Maldives requires effective e-learning readiness for higher education students. Challenges include academic anxiety, low self-regulation in learning, and the need for support in writing scientific papers. PL platforms address these challenges by providing tailored student support based on needs and learning styles. The connection between formative assessments on Moodle and self-regulatory learning skills in blended learning students underscores the significance of PL approaches in improving student outcomes. Predicting the utilization of PML through LMS aims to address pre-university students' readiness and support needs in the Maldives, ultimately improving academic success and learning experiences. This study seeks to explore the factors that predict the adoption and effective use of LMS, particularly Moodle, for PML among pre-university students in the Maldives. The main research question is: "what factors influence the utilization of PML through LMS among pre-university students in the Maldives?" The hypothesis posits that variables, such as performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and student commitment (SC) play a significant role in shaping LMS usage behavior (UB) in PML environments.

Investigating LMS usage via Moodle is indispensable for aiding educators in evaluating students' understanding of online instruction. Educators must explore diverse methodologies to cater to students' needs. Integrating LMS on Moodle within the Maldivian education system is essential, necessitating strategic plans for advancing educational systems. This necessity arises from a deficiency in knowledge, expertise, and limited proficiency in data literacy among educators utilizing Moodle [26]–[28]. Assessing the current use of personalized mathematics education through LMS among pre-university students in the Maldives is vital for repurposing existing data for educational ends. The objective is to enhance the education system by adopting modern LMS strategies and techniques. A study on students' and teachers' perceptions of using LMS reveals that they remain unconvinced about the necessity of Moodle [27]. Students' acceptance of Moodle is essential to understanding how well teachers accept and use it in mathematics and facilitation.

This study takes a novel approach by investigating the factors that predict the adoption and use of a LMS, specifically Moodle, in the context of PML. It focuses on the relationship between the utilization of Moodle for personalized mathematics education and variables, such as EE, PE, SC, SI, and FC. This research contributes to our understanding of how these factors impact the effective implementation and acceptance of technology-enhanced learning environments in the field of mathematics education. This unique investigation aims to provide insights into the factors that drive the successful integration of LMS platforms such as Moodle in PML settings, which will be valuable for educators, researchers, and policymakers to enhance technology-driven educational practices in mathematics education.

2. METHOD

This study employed a correlational research design among pre-university students enrolled in the Centre for Foundation Studies Certificate level 4 courses during Term II of 2023. It used LMS (Moodle) at the Maldives National University. A total of 120 students were randomly chosen from a group of 556 to participate in the study. An online questionnaire (Google Forms) was used to collect the data. The questionnaires comprised five independent variables: PE, EE, SI, FC, SC, and the dependent variable (UB of LMS in PML). Five educational technology and mathematics experts validated the instrument, confirming that the items accurately measure variables. To assess the use of LMS (Moodle), 30 items were altered and modified to meet the needs of the study context, and then validated. The items' purpose is to evaluate the use of LMS (Moodle) based on students' learning behavior through technology, supplement learning materials and tools, monitor students' individualized learning strategies, and overall focus on students' learning experiences and mathematics outcomes. The items of the variables, namely PE, EE, SI, and FC, were modified versions of the original instrument by Venkatesh *et al.* [29].

Furthermore, the items developed for the variable SC originate from Wilkins *et al.* [30], UB items altered to the research context [31], [32]. The PML instrument in LMS was proved as a reliable measurement scale with exploratory analysis for each variable, resulting in Cronbach's alpha values for each variable: PE (0.911), EE (0.803), SI (0.765), FC (0.709), SC (0.878) and UB (0.837). According to Hair *et al.* [33], the internal consistency of this research instrument exceeds the threshold of 0.70, which signifies that it is an acceptable and dependable tool for research.

The data collected were analyzed using IBM SPSS statistics version 25.0. Descriptive statistics, including means and standard deviations (SD), were calculated to summarize the respondents' perceptions and intentions regarding LMS utilization in PML. Pearson correlation analysis was conducted to determine the strength and direction of relationships between the independent variables (PE, EE, SI, FC, and SC) and the dependent variable (LMS UB).

Additionally, multiple regression analysis was carried out to predict the factors influencing LMS UB, providing R, R^2, and adjusted R^2 values to evaluate the model's explanatory power. An analysis of variance (ANOVA) was used to test the overall significance of the regression model, and regression coefficients were analyzed to identify the relative contribution of each predictor variable. The regression equation developed from this analysis helps understand the combined impact of the predictors on LMS UB in PML settings.

Ethical clearance for conducting this research was acquired from the ethical review committee of the MNU. All participants provided informed consent before participating in the study. They were assured that their responses would remain confidential and anonymous and were informed of their right to withdraw from the study at any time without any consequences.

3. RESULTS AND DISCUSSION

3.1. Descriptive statistics

Table 1 provides a detailed descriptive analysis, including the mean and SD for each variable, offering a clear summary of the data distribution and central tendencies across the study's key metrics. The overall mean for UB is 3.667 (SD=0.629), which means the respondents intend to use LMS in PML.

The overall mean for the dimension PE is 3.780 (SD=0.664), indicating that respondents believe that using the LMS platform in PML can enhance their learning experience/performance. The overall mean of EE is 3.705 (SD=0.655), indicating respondents' approval of the ease of utilizing the LMS technology in PML. Similarly, the respondents' overall mean for SI is 3.316 (SD=0.826), demonstrating the beneficial impact of utilizing the LMS (Moodle) on improving their learning experience.

Furthermore, the overall mean of the dimension FC 4.078 (SD=0.579) illustrates the guarantee of facilities and additional aid provided to respondents to utilize the LMS (Moodle) in the PL environment. Therefore, the overall mean score of the dimension of SC towards using LMS technology in PML is 4.005 (SD=0.750), which shows respondents' commitment to improving their learning experience. The results obtained in the present study is consistent with previous studies [26], [34], [35], where utilization of the LMS platform enriches students' mathematics performance.

Table 1. Mean and SD

Variable	Mean	Std. Deviation
UB	3.6667	0.62944
PE	3.7800	0.66479
EE	3.7050	0.65540
SI	3.3167	0.82628
FC	4.0783	0.57994
SC	4.0050	0.75078

3.2. Inferential statistics

Pearson correlation analysis was conducted to examine the association between each study variable and LMS UB in PML. The results, as presented in Table 2, indicate a moderately positive relationship between PE and LMS utilization in PML (r=0.624**, p=0.000). This indicated students' acceptability and usefulness of using LMS in PML, implying that students inspire their learning experience through the Moodle platform to improve their performance. Likewise, the results demonstrate a moderately significant positive relationship between EE and UB of LMS in PML (r=0.644**, p=0.01). This signifies the consideration of the use of LMS by students, and average students accept the use of LMS as a comfortable platform and its ease of use in navigating the learning activities, assigned tasks, and Moodle tools in PML; ultimately, this will make them use Moodle platform with more regularly. This finding is in tandem with other studies using LMS [26], [25], [36]. Similarly, a moderate positive relationship was found between FC and LMS UB in PML utilization (r=0.533**, p=0.01), indicating that good technical support is provided for students in times of need, resulting in minimal interruptions and encouraging students to use LMS frequently to improve PML. Other studies have also found a significant positive relationship between FC and LMS use behavior among students [36], [37]. Consequently, a significant moderately positive linear relationship was observed between SC and UB (r=0.696**, p=0.01), which indicates the utilization of LMS in PML can improve student participation that can boost the use of the platform creating a more inducive PML experience. This result was supported by findings from prior studies [38], [39].

The findings of the Pearson correlation also establish a weak positive relationship between SI and UB in PML (r=0.204*, p=0.05). This describes the encouragement required from tutors, peers, or family members towards students using the technology LMS (Moodle) in PML. Thus, the users require a push to make them aware of using the platform to achieve their learning goals by adopting technology. The result obtained in the present study is consistent with the findings of previous studies [40], [41].

Table 2. Pearson correlation test results

	PE	EE	SI	FC	SC
UB of LMS in PML utilization	0.624**	0.644**	0.203*	0.533**	0.696**

3.3. Regression analysis

The study employs multiple regression analysis to predict the factors—PE, EE, SI, FC, and SC—that influence the UB of LMS among pre-university students in higher education. Table 3 presents the R, R^2, and R^2 displacement values, along with the standard random assumptions, to depict the regression model based on implementing LMS in PML. The summary of the multiple regression model indicates a significant correlation (R) value of 0.807, showing the standard for considering the predictors in PML using LMS. The research findings reveal an R^2 value of 0.651, which signifies the extent of variance in the dependent variable. Furthermore, the R^2 displacement value is 0.636, describing the linear regression value of the five independent variables contributing 63.6% of the variance toward using LMS in PML.

Table 3. Regression model

Model	R	R^2	R^2 displacement	Std. Random assumption
1	0.807[a]	0.651	0.636	0.38001

Predictors: (constant), SC, SI, FC, EE, PE; Dependent variable: UB

3.4. Analysis of variance

Table 4 displays the ANOVA results, which underscore the importance of multiple variables in predicting the utilization of LMS for PML. The ANOVA results provide a comprehensive understanding of how each factor contributes to the overall model, emphasizing the significance of these variables in influencing LMS UB. The F statistic yielded a substantial F (5, 114)=42.497, indicating significant differences among the examined groups. Furthermore, the associated p-value of 0.000, well below the commonly accepted threshold of 0.05, emphasizes the statistical significance of these findings. As a result, we can conclude that the combined characteristics examined in this study have a significant impact on adopting and deploying LMS inside PML learning contexts. These results underscore the significance of considering various factors when implementing LMS solutions in educational settings, elucidating the relationship between these variables and their influence on instructional pedagogies.

3.5. Estimated model coefficients for predicting LMS utilization in personalized mathematics learning

Table 5 presents estimated coefficients from a regression analysis. Several predictor variables show statistically significant associations with LMS usage. Both EE and PE have positive relationships with LMS utilization, indicating that interactions among peers and experts contribute to the increased adoption of LMS platforms. On the other hand, SI demonstrates a modest inverse relationship with LMS usage, suggesting that higher levels of complexity may slightly hinder LMS adoption in PML settings. FC has a positive association with LMS utilization, indicating that effective FC fosters greater adoption of LMS. The findings suggest that SC is the most influential factor, contributing to 40.6% of the overall usage of LMS in PML. This highlights the crucial role that student dedication plays in effectively utilizing LMS platforms, making it the strongest predictor among the variables analyzed. Thus, SC is the strongest predictor, showing a substantial positive relationship with LMS utilization. This emphasizes the crucial role of student involvement in complex tasks in driving the adoption of LMS in PL environments. Hence, the findings highlight the importance of PE, EE, FC, and SC in facilitating the integration of LMS technology in learning mathematics. SC has been reported as a critical factor and predictor supporting LMS acceptance in other studies [42], [43]. Therefore, SC is essential in accepting the use of LMS in PML. Thus, this approach to teaching and learning can improve students' progress and monitor the integration of LMS and its application into one of the online instructional techniques. Therefore, the general equation of the model for predictive students' use of LMS in PML, as in (1).

$$\hat{Y} = 0.158x_1 + 0.261x_2 + 0.230x_3 + 0.340x_4 + 0.097 \quad (1)$$

Where, x_1=PE; x_2=EE; x_3=FC; x_4=SC.

Table 4. ANOVA regression model

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	30.684	5	6.137	42.497	.000[b]
	Residual	16.462	114	0.144		
	Total	47.147	119			

a. Dependent variable: UB
b. Predictors: (constant), SC, SI, FC, EE, PE

Table 5. Estimated model for coefficients

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	Beta	Std. Error	Beta		
(Constant)	0.097	0.286		0.340	0.735
PE	0.158	0.079	0.167	2.008	0.047
EE	0.261	0.077	0.272	3.383	0.001
SI	-0.090	0.046	-0.118	-1.954	0.053
FC	0.230	0.070	0.211	3.257	0.001
SC	0.340	0.063	0.406	5.378	0.000

Based on the results, integrating LMS within PML environments appears promising in enhancing students' educational experiences and performance in PML. Descriptive statistics from Table 1 shed light on respondents' perceptions and intentions regarding LMS utilization in PML. Positive mean scores across

dimensions such as SI, PE, FC, SC and EE highlight students' favorable attitudes toward integrating LMS technology into their learning experiences. These findings align with prior research [44], [45], confirming the positive impact of LMS platforms on students' mathematics performance.

Furthermore, inferential statistics presented in Table 2 further clarify the relationships between crucial predictor variables and LMS UB in PML. Notably, variables such as EE, FC, PE, and SC show moderate to strong positive correlations with LMS utilization, underscoring their essential roles in shaping students' adoption patterns. These findings emphasize the significance of ease of use, perceived usefulness, technical support, and student engagement in driving effective LMS integration within PML settings. Moreover, regression analysis summarized in Table 3 provides additional insights into the predictive power of these variables on LMS utilization, with the combined factors explaining a significant portion of the variance. The subsequent ANOVA confirms the collective impact of these variables on LMS adoption, highlighting their instrumental role in shaping instructional pedagogies and improving learning outcomes. These findings collectively support a holistic approach to promoting effective LMS integration in educational practices, aiming to create engaging, interactive, and PL environments that contribute to student success.

The study's findings provide a comprehensive understanding of the key factors driving the utilization of LMS for PML among pre-university students at the MNU. The data analysis revealed strong, positive correlations between LMS UB and the four primary predictors: PE, EE, FC, and SC, with SC identified as the most significant predictor. The positive relationship between PE (r=0.624) and LMS UB suggests that when students believe the LMS will enhance their learning outcomes, they are more inclined to use the system. This is consistent with the principles of the technology acceptance model (TAM), which emphasizes the role of perceived usefulness in the adoption of new technologies.

Moreover, the strong correlation between EE (r=0.644) and LMS usage behavior highlights the importance of ease of use in promoting consistent engagement with LMS platforms. This supports the unified theory of acceptance and use of technology (UTAUT) model, which points to the critical role of user-friendly design in encouraging technology adoption. The findings imply that when LMS platforms are intuitive and easy to navigate, students are more likely to integrate them into their learning routines.

FC also showed a positive impact, suggesting that adequate resources, support, and infrastructure are crucial in enabling effective use of LMS for PML. The fact that SC was the strongest predictor underscores the pivotal role of student motivation and dedication in the successful adoption and utilization of LMS in educational settings. Thus, these insights underscore the requirement for educational institutions to focus on enhancing these key factors—particularly by improving the perceived usefulness and ease of use of LMS platforms, ensuring robust FC, and fostering strong SC—to maximize the effectiveness of LMS in PL environments. FC (r=0.533) was another significant predictor, underscoring the role of adequate technical support and resources in LMS utilization. Reliable infrastructure, such as stable internet connections and accessible technical assistance, is essential to minimize disruptions and encourage continuous use of LMS for PL. SC (r=0.696) emerged as the strongest predictor of LMS usage behavior, highlighting the critical role of student engagement and motivation in the effective use of LMS. Committed students are more likely to leverage LMS platforms to enhance their learning experiences. This suggests that fostering a culture of commitment and responsibility among students can significantly impact the success of LMS integration. Although SI (r=0.204) showed a weaker positive relationship with LMS usage behavior, it still indicates that encouragement from peers, family, and instructors can play a role in technology adoption. However, its weaker impact compared to other factors suggests that SI alone is not sufficient to drive LMS utilization without the support of other more influential factors like performance and EE.

The results emphasize the critical need to address key factors like PE, EE, FC, and SC to enhance LMS UB in PML environments. These insights are invaluable for educators and policymakers aiming to refine technology-driven educational practices. Institutions can boost student engagement, motivation, and academic performance by concentrating on these predictors, particularly in mathematics education.

The study's findings have significant practical implications for both educational practice and policy. They highlight the importance of integrating PL paths into the curriculum, ensuring that each student's unique learning needs and preferences are met. Also, the study stresses the need for robust learner support systems, which are crucial in helping students navigate and efficiently use LMS platforms. By incorporating these elements, educational institutions can establish a more supportive and PL environment, which not only enhances the learning experience but also maximizes the impact of LMS on student outcomes. Furthermore, these findings suggest that policymakers should focus on creating policies that support the development and implementation of user-friendly, resource-rich LMS platforms. By doing so, they can ensure that the technological infrastructure in education is aligned with the needs of students and teachers, ultimately leading to improved educational practices and better learning outcomes.

Curriculum developers should incorporate these strategies to improve student engagement and performance in mathematics. Also, educators need sufficient training in utilizing LMS platforms effectively.

Professional development programs should focus on improving teachers' proficiency in managing and integrating LMS tools in their instructional practices. Besides, proper implementation of PL practices needs adequate resources, manpower, and time. Educational institutions should ensure that these resources are available to support the successful integration of LMS in PML. Policymakers should consider the benefits of PL and LMS usage in enhancing student outcomes. Policies should support developing and implementing technology-enhanced learning environments, particularly in regions with unique challenges like the Maldives. PL platforms should address challenges such as academic anxiety, low self-regulation, and the need for support in writing scientific papers. Tailored student support based on individual needs and learning styles is essential for improving academic success.

4. CONCLUSION

This study provides empirical evidence supporting the use of LMS to enhance PML. Descriptive statistics indicate that respondents have positive attitudes and intentions towards using LMS in PML. Inferential statistics revealed significant positive correlations between key predictor variables (EE, PE, FC, SC) and LMS utilization, underscoring their crucial role in shaping adoption patterns. Regression analysis further substantiates the predictive power of these variables on LMS usage, highlighting the nature of factors influencing adoption. Variance analysis emphasizes these variables' collective impact on LMS utilization, highlighting their significance in shaping instructional pedagogies and enhancing learning outcomes. These findings advocate for a comprehensive approach to promoting effective LMS integration in educational practices, aiming to foster engaging, interactive, and PL environments that facilitate student success.

Drawing from the findings of this study, several recommendations are proposed to enhance the adoption and effective use of LMS for PML. Incorporation of PL paths and robust learner support systems into the curriculum to improve student engagement and performance in mathematics. Provision of professional development programs focusing on improving educators' proficiency in managing and integrating LMS tools into their instructional practices. Also, educational institutions should allocate adequate resources, manpower, and time to support the successful implementation of PL practices using LMS. Policymakers should support developing and implementing technology-enhanced learning environments, especially in regions with unique challenges like the Maldives, by considering the benefits of PL and LMS usage in improving student outcomes. Student support: address challenges such as academic anxiety, low self-regulation, and the need for support in writing scientific papers by providing tailored student support based on individual needs and learning styles. Implementing these recommendations can help advance the education system by utilizing modern LMS strategies and techniques, ultimately enhancing students' academic success and learning experiences. Therefore, these findings advocate for a comprehensive approach to promoting effective LMS integration in educational practices, aiming to foster engaging, interactive, and PL environments that facilitate student success.

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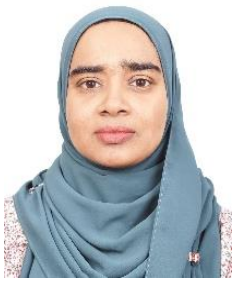
BIOGRAPHIES OF AUTHORS



Mausooma Mohamed is a Doctoral student, in the field of Mathematics Education at the Institute for Mathematics Research, Universiti Putra Malaysia, Serdang, Selangor, Malaysia. She is a lecturer at the Centre for Foundation Studies, The Maldives National University, Maldives. Her research is focused on personalized mathematics learning strategies in mathematics education by utilizing a learning management system among pre-university students. She can be contacted at email: mausooma.mohamed@mnu.edu.mv.

Ahmad Fauzi Mohd Ayub is a Professor at the Department of Foundation of Education, Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia. His research interest involved projects in the fields of mathematics education, educational technology, learning management systems and multimedia education. He can be contacted at email: afmy@upm.edu.my.

Maizura Yasin is a Senior Lecturer in the Department of Languages and Humanities Education, Faculty of Educational Studies, Universiti Putra Malaysia. Her expertise is in moral education, values education and educational psychology, especially in teaching, research, consultancy and community service. She focuses more on research on the psychology of moral education. She can be contacted at email: y_maizura@upm.edu.my.

Nur Raihan Che Nawi is a Senior Lecturer in the Department of Professional Development and Continuing Education at the Faculty of Educational Studies, Universiti Putra Malaysia (UPM). She obtained her Ph.D. in the field of Human Resource Development, specializing in Youth Development. With extensive research experience before joining UPM, she teaches courses such as research methods, philosophy and principles of extension education and thinking skills. Additionally, she is an expert in qualitative research design. She can be contacted at email: nurraihan@upm.edu.my.