

BUKTI KORESPONDENSI
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Judurl Artikel : **Effectiveness of using learning management system for pre-service primary school teachers**

Jurnal : **Multidisciplinary Science Journal**
[Vol. 8 Issue 3 \(2026\)](#), e2026148 | **Published in 21 August 2025**

Penulis : Trisni Handayani, Marisa Ana Tiara, Abu Bakar Ahmad Mansor, Zulherman

No	Prihal	Tanggal
1	Bukti Konfirmasi submit	26 April 2025
2	Bukti konfirmasi review dan hasil review pertama	4 Juli 2025
3	Bukti konfirmasi review dan hasil review kedua	8 Juli 2025
4	APC dan Copyediting	11 Juli 2025
5	Bukti konfirmasi review Minor Corrections	14 Juli 2025
6	Bukti Proof Reading dan APC	26 Juli 2025
7	Article has been published	21 Agustus 2025

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Recommendation: **Accepted for Publication** with *Minor corrections*.

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Effectiveness of Using Learning Management System for Pre-Service Primary School Teachers



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Abstract

The use of Learning Management Systems (LMS) has become an essential tool in the teaching and learning process in education. However, its effectiveness in enhancing the professional competencies of *prepre*-service teachers requires further investigation. This study aims to evaluate the effectiveness of LMS use and teacher participation in developing the professional competencies of *prepre*-service teachers in primary schools. A quantitative research method was employed, utilizing structural model analysis techniques involving 87 *prepre*-service teachers. Data were collected through a questionnaire designed to assess the validity and reliability of the model, as well as to examine the influence of independent variables on the dependent variable. Data analysis was conducted using SmartPLS software, and the results indicated that LMS utilization had a significant and substantial impact on improving teachers' professional competencies. Meanwhile, teacher participation had a lower but still significant effect. The findings demonstrate that LMS usage contributes significantly to the enhancement of teachers' professional competencies, while teacher participation also has a meaningful, albeit smaller, impact. The integration of LMS into teacher training programs plays a crucial role in strengthening the professional competencies of *prepre*-service teachers. At the same time, active teacher participation, although less influential, still has a positive impact. These results provide practical implications for policymakers and educators in designing effective training programs. This study highlights the importance of leveraging LMS technology to enhance educational quality and improve teacher training effectiveness.

Keywords: Learning management system, Primary school teacher, Professional Competencies, Adoption Technology, Technology User.

1. Introduction

In modern education, technology has become a key catalyst in transforming teaching and learning methods (Kaimara et al., 2021). Technology significantly influences advancements in the education sector, enabling the development of various educational platforms that facilitate distance learning. One of the increasingly dominant technologies in teacher training is the Learning Management System (LMS) (Abdul Hamid et al., 2020). As a cornerstone of the education system, teachers are responsible not only for delivering instructional content but also for creating a supportive learning environment, motivating students, and adapting teaching methods to meet individual needs (Marbân & Mulenga, 2019). Primary education serves as the foundation for students' skill and competency development, which will shape their academic and professional trajectories in the future (Sulaiman, 2024). Therefore, teachers play a crucial role in ensuring that the learning process is effective and efficient.

PrePre-service teachers, who are in the early stages of their careers, bear a significant responsibility in developing innovative and responsive teaching methods to address students' needs (Tran et al., 2020). Teachers are considered professionals when they have mastered four core competencies: pedagogical competence, personal competence, professional competence, and social competence (Panagiotarou et al., 2020). However, achieving this requires adequate support, both in terms of access to educational resources and relevant training. A conducive learning environment and appropriate technological support play a vital role in helping them grow into competent educators (Olschewski et al., 2023). This is where Learning Management Systems (LMS) can play a crucial role.

LMS is a highly valuable tool for providing broad and flexible access to high-quality learning resources, with its utilization process facilitated online through LMS support (Wilkinson et al., 2020). LMS offers various features that enable learning to become more flexible, structured, and interactive (Torakulovich, 2024). It is a software platform designed to develop, deliver, and manage courses, learning resources, activities, and assessments (Letsoalo, 2024). However, the

effectiveness of [an LMS](#) in enhancing teachers' professional competencies ~~does depends~~ not ~~solely-dependently~~ on the availability of the technology but also on the active participation of [prepre-service](#) teachers in the learning process. A high level of participation indicates greater engagement and commitment from teachers in utilizing LMS, which, in turn, can improve learning outcomes (ElSayary et al., 2024). Conversely, using [an LMS](#) without adequate participation may not yield a significant [impacts effect](#) on the enhancement of teachers' professional competencies. Therefore, it is crucial to explore how LMS usage and [pre-servicepreservice](#) teacher participation interact to influence their professional competencies.

The Teacher Professional Education Program is an initiative aimed at enhancing and updating educators' knowledge and skills, enabling them to navigate the dynamics and complexities of the education sector (Dindar et al., 2021). By gaining a deeper understanding of how [LMSLMSs](#) can support the professional development of [prepre-service](#) teachers, ~~it-is-expected~~ that the quality of primary education can be improved, ~~preparing-future-teachers-to-be-more-competent-and-innovative-The~~ [Pre-serviceincreasing the competence and innovativeness of future teachers. The Preservice](#) Teacher Professional Education Program (PPG Prajabatan) is professionally designed to ensure that [pre-servicepreservice](#) teachers are well-prepared to educate with the support of [LMSLMSs](#). LMS allows teachers to design and manage curricula more efficiently, assign tasks and assessments, and monitor student progress in real-time. However, there remains a gap between the training and technical support available and teachers' actual ability to integrate technology into their teaching practices. Many [prepre-service](#) teachers may be unfamiliar with or lack confidence in utilizing technology for instruction, thus requiring adequate training and technical support (Sahal & Ozdamir, 2020). Institutional support is also crucial for the successful implementation of [an LMS](#). School administrations and government bodies must provide supportive policies, funding for technological infrastructure, and continuous professional training for teachers. Therefore, this study aims to explore the effectiveness of [LMSLMSs](#) in the professional development of [prepre-service](#) primary school teachers, while also identifying ~~its~~[their](#) benefits, challenges, and relevant solutions (Toktarova & Semenova, 2020). ~~The-research-seeks~~[Research has sought](#) to examine how [LMS influencesLMSs influence](#) various aspects of teaching skill development among prospective teachers.

1.1. LMS Useuse (LU)

The effective use of [an LMS](#) is predicted to have a significant [impacts effect](#) on enhancing the professional competence of [prepre-service](#) teachers (Sittisak et al., 2022). LMS provides various tools and resources that support the learning process, such as access to educational materials, discussion forums, online assessments, and instant feedback. By utilizing [LMS; pre-serviceLMSs, preservice](#) teachers can deepen their understanding of pedagogical content, improve [their](#) technological skills, and implement more innovative teaching strategies. The professional competencies gained from LMS usage include teaching planning, classroom management, and learning assessment, all of which are key elements in the teaching profession (Umam et al., 2024).

1.2. Teacher Participation (TP)

The active participation of [prepre-service](#) teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where [prepre-service](#) teachers not only receive information but also actively interact with content and peers-. In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, [prepre-service](#) teachers' participation in [LMSLMSs](#) will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

1.3. Professional Teacher Competence (PTC)

The active participation of [prepre-service](#) teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where [prepre-service](#) teachers not only receive information but also actively interact with content and peers (Flores-Cáceres et al., 2022). In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, [prepre-service](#) teachers' participation in [LMSLMSs](#) will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

2. Method

2.1 Research Design

This study employs a quantitative approach [usingwith](#) a questionnaire method to measure the impact of LMS utilization and teacher participation on teachers' professional competence (Dahal & Manandhar, 2024). The research method applied is a structural model, where data [isare](#) analyzed [usingvia](#) statistical software that supports model testing. The

variables measured in this study include LMS utilization, teacher participation, and professional competence as latent variables.

2.2 Validity and Reliability Measurement

The validity and reliability of the measurement model (outer model) were tested using several indicators (Rahmi et al., 2024). Convergent validity was assessed by examining the loading factor values of each indicator, where values greater than 0.70 are considered valid (Fadhli et al., 2023). Furthermore, construct reliability was tested using Composite Reliability (CR) and Cronbach's Alpha, with a CR value greater than 0.70 indicating that the latent variable possesses good and consistent reliability. Convergent validity was also evaluated through the Average Variance-Extracted (AVE) value, where a value above 0.50 signifies that the indicators exhibit good convergent validity.

2.3 Discriminant Validity

Discriminant validity was tested using two methods: the Heterotrait-Monotrait Ratio (HTMT) and the Fornell-Larcker criterion (Sims, 2024). An HTMT value of less than 0.90 indicates good discriminant validity, meaning that indicators measuring a specific variable exhibit higher correlations with items within that variable compared to items in other variables. The Fornell-Larcker approach assesses discriminant validity by comparing the square root of the Average Variance-Extracted (AVE) with the correlations between latent variables. Discriminant validity is considered fulfilled if the square root of the AVE of a latent variable is greater than its correlation with any other latent variable.

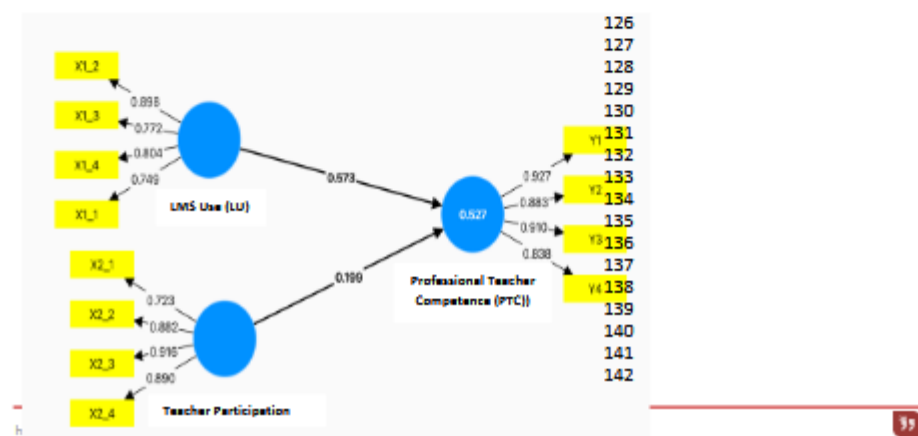
2.4 Multicollinearity Test and Structural Model

To ensure the absence of multicollinearity among variables in the structural model, the Variance-Inflated Factor (VIF) values were examined (Kassim, 2024). A VIF value of less than 5 indicates no significant multicollinearity. Following the multicollinearity test, the influence of LMS Usage and Teacher Participation on Teacher Professional Competence was analyzed using the structural model. The magnitude of the influence was assessed based on the path coefficient and f-square values, where a higher f-square value indicates a more significant effect.

3. Results

3.1 Convergent Validity

The path diagram displayed in Smart-PLS illustrates the relationships between LMS utilization, teacher participation, and the professional competence of pre-service primary school teachers (Wang et al., 2021). In this diagram, LMS utilization is represented by four indicators, each exhibiting a high loading factor, indicating that these indicators strongly reflect the latent variable of LMS utilization. All indicators used in this study have loading factor values above 0.70, demonstrating good convergent validity.



In Figure 1, the X1_2 indicator has a loading factor of 0.898, indicating that this indicator validly measures the LMS Usage variable (Herwin et al., 2022). This suggests that any changes in the LMS Usage variable are significantly reflected in variations in the X1_2 indicator, with a contribution value of 80.6% (0.898×0.898). Overall, all indicators measuring the latent variables in this study have met the criteria for good convergent validity.

3.2. Construct Reliability

Construct reliability was measured using Cronbach's Alpha and Composite Reliability values. The Cronbach's Alpha and Composite Reliability (CR) values for each latent variable exceeded 0.70, indicating that these variables are consistent and reliable in measurement (Santoso et al., 2023).

Table 1 Construct Reliability

Construct Reliability-Validity	Cronbach Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted
Professional Teacher Competence (PTC)	0.913	0.920	0.938	0.793
Teacher Participation (TP)	0.880	0.918	0.916	0.733
LMS Use (LU)	0.823	0.845	0.882	0.652

In Table 1 shows that the variable Teacher Professional Competence has a Composite Reliability value of 0.938, indicating that the indicators measuring this variable are consistent and reliable. This high CR value suggests that the latent variable in this study can be trusted to accurately and consistently measure the intended concept.

3.3. Discriminant Validity

Discriminant validity was tested using the Heterotrait-Monotrait Ratio via the heterotrait-monotrait ratio (HTMT) method and the Fornell-Larcker criterion. In the table 2 show analysis results indicate Table 2 shows that the HTMT values for each pair of variables are less than 0.90, confirming that discriminant validity has been achieved (Astuti et al., 2022).

Table 2 Discriminant Validity (HTMT)

Discriminant Validity (HTMT)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.646		
LMS Use (LU)	0.792	0.782	

In other words, the variables in this model exhibit a higher correlation with their own indicators than with the indicators of other variables, ensuring that each latent construct is truly unique and distinct from the others. Table 3 presents the results of the Fornell-Larcker analysis, indicating that the square root of the AVE for the Professional Competence variable is 0.890, which is greater than its correlation with other variables in the model. This demonstrates that each latent variable possesses good discriminant validity, meaning that the indicators are more strongly correlated with their respective latent variables than with other variables (Kusumajati & Chairiyani, 2024).

Table 3 Discriminant Validity (Fornell-LC)

Discriminant Validity (Fornell-LC)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)	0.890		
Teacher Participation (TP)	0.599	0.856	
LMS Use (LU)	0.712	0.697	0.808

3.4. The Influence of LMS Use and Teacher Participation

Table 4 Path Coefficients

Path Coefficients- Confidence Interval	Original sample (O)	Sample mean (M)	2.5%	97.5%
Teacher Participation (TP) >>> Professional Teacher Competence (PTC)	0.199	0.203	0.059	0.337
LMS Use (LU) >>> Professional Teacher Competence (PTC)	0.573	0.539		0.722

In tableTable 4-on, regarding path coefficients, the use of the Learning-Management-Systemlearning management system (LMS) is shown to have a significant impacteffect on Teacher-Professional-Competenceteacher professional competence, with a path coefficient of 0.573. This finding indicates that an increase in LMS usage will-significantly enhanceenhances Teacher Professional Competence (Yang & Kaiser, 2022). Additionally, Teacher Participation also-has a significant influence on Teacher Professional Competence, although its effect is smaller, with a path coefficient of 0.199. This suggests that while teacher participation is important, its impact is not as substantial as LMS usage in improving teacher professional competence.

3.5. R-Square

Table 5 R-square

R-square	R-square	R-Square adjusted
Professional Teacher Competence (PTC)	0.527	0.517

Table 5 shows that the R-Squaresquare value of 52.7% indicates that the model explains 52.7% of the variability in Teacher Professional Competence through LMS usage and Teacher Participation. According to Hair et al., this represents a moderate effect. Additionally, the F-Squaresquare value illustrates the magnitude of the influence of each independent variable on the dependent variable at the structural level (Wuisan et al., 2023).

3.6. f-square

Table 6 f-square

f-square	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.043		
LMS Use (LU)	0.357		

Table 6 shows that LMS usage has a high impact on Teacher Professional Competence, with an F-Square value of 0.357, whereas Teacher Participation has a low impact, with an F-Square value of 0.043. This confirms that compared with teacher participation, LMS usage is a more dominant factor in determining Teacher-Professional-Competence-compared-to teacher-participationteacher professional competence (Guillén-Gómez et al., 2023).

4. Discussion(Su & Chen, 2025)

The importance of institutional support, such as favorable policies, funding for technological infrastructure, and continuous training for teachers, is crucial (Hennessy et al., 2022). This support plays a vital role in ensuring the successful implementation of LMSLMSs in teacher training programs. Furthermore, this study highlights that LMS utilization not only provides flexibility in accessing educational resources but also enables personalized learning tailored to individual needs and capabilities (Haddade et al., 2024). The findings indicate that integrating LMSLMSs into teacher training programs significantly contributes to enhancing prospective teachers' professional competencies (Arifin et al., 2023). LMS allows prospective teachers to access various learning resources more flexibly and efficiently while also supporting more personalized learning experiences (Farooq et al., 2014). Other studies have foundshown that the use of Learning Management-Systems-(LMS-Uselearning management systems (LMS) has a significant positive impacteffect on the quality of

teacher competence (Alserhan & Yahaya, 2021). Another study by Runge et al., (2023) also [indicated](#) that LMS use plays a role in enhancing teacher competence, where the integration of technology, such as [LMS/LMSs](#) in learning, influences learning outcomes and is supported by strong teacher competence. The opposite findings suggest that LMS use does not impact teacher competence [due-to-because of](#) factors such as limitations in online interaction (Annamalai et al., 2021). Another study by (Benjamin Aidoo et al., 2022) also [found-revealed](#) that ICT training for teachers does not impact their ability to conduct online learning. Instead, the training [primarily-focuses](#) [primarily](#) on developing skills to organize and prepare digital teaching materials, rather than enhancing their ability to teach online [using-via](#) an LMS.

The significant impact of LMS [Use/use](#) (LU) has practical implications for policymakers and educators in designing effective training programs (Limantara et al., 2023). LMS not only facilitates the teaching and learning process but also supports the professional development of prospective teachers. While teacher participation also has an influence, these findings emphasize the importance of leveraging technology in teacher training and professional development. This study confirms that LMS utilization is a key factor in helping prospective teachers prepare to become competent and professional educators in the digital era (Elfeky & Elbaly, 2021). Additionally, adequate institutional support and policies are essential [to-for](#) ensuring the successful implementation of [LMS/LMSs](#) in teacher training programs (AL-Nuaimi et al., 2022). [The-A](#) study by Rizal et al., (2022) [found-revealed](#) that the role of teachers participating in training significantly influences competency improvement. Through training, teachers become more accustomed to preparing digital teaching materials, which in turn streamlines other instructional processes. [Meanwhile-Moreover](#), other studies have [also-found-reported](#) that the active participation of teachers in training has a positive [impact-effect](#) on their competencies. This is because the focus and target of mastering new skills play [a-crucial](#) [role-roles](#) in enhancing the quality of teachers' competencies (de-Torres et al., 2024).

5. Conclusions

Overall, [the](#) LMS is a highly effective tool [in-for](#) supporting the education of prospective elementary school teachers, particularly in preparing them to face the challenges of education in the digital era. Effective LMS utilization can enhance interaction, [facilitate](#) access to information, and strengthen prospective teachers' pedagogical skills. However, to achieve maximum effectiveness, it is crucial to ensure that [the](#) LMS is well integrated into the curriculum and accompanied by adequate training for prospective teachers. The success of [an](#) LMS also depends on how well prospective teachers can transfer the skills they acquire into real teaching practices in schools. Therefore, continuous evaluation and improvement of LMS usage are necessary to [holistically-support](#) educational objectives.

Acknowledgment

We would like to express our deepest gratitude to all [the](#) parties who [have-contributed](#) to the writing of this article. We sincerely appreciate the contributions, support, and assistance from various individuals and institutions who have dedicated their time, effort, and valuable insights. Our heartfelt thanks also go to those whose names are not mentioned but have contributed in various ways to the success of this article.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare [that they have](#) no conflicts of interest.

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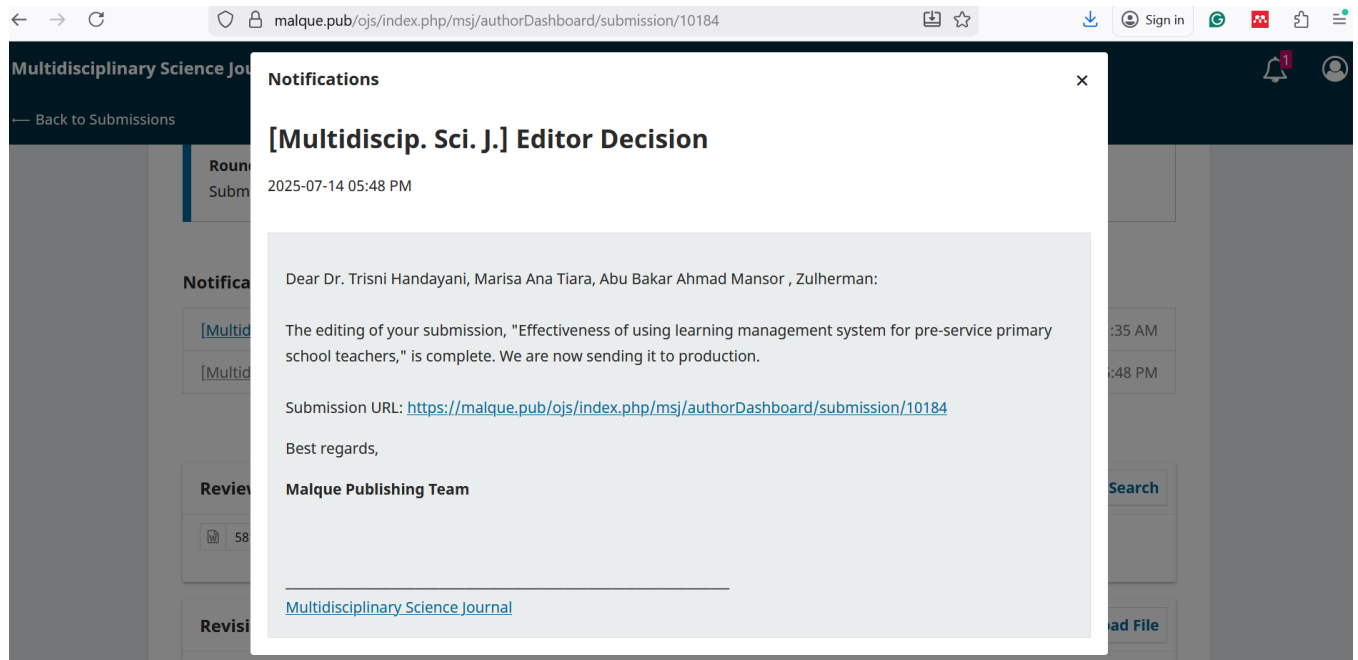
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Effectiveness of Using Learning Management System for Pre-Service Primary School Teachers



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Abstract

The use of Learning Management Systems (LMS) has become an essential tool in the teaching and learning process in education. However, its effectiveness in enhancing the professional competencies of pre-service teachers requires further investigation. This study aims to evaluate the effectiveness of LMS use and teacher participation in developing the professional competencies of pre-service teachers in primary schools. A quantitative research method was employed, utilizing structural model analysis techniques involving 87 pre-service teachers. Data were collected through a questionnaire designed to assess the validity and reliability of the model, as well as to examine the influence of independent variables on the dependent variable. Data analysis was conducted using SmartPLS software, and the results indicated that LMS utilization had a significant and substantial impact on improving teachers' professional competencies. Meanwhile, teacher participation had a lower but still significant effect. The findings demonstrate that LMS usage contributes significantly to the enhancement of teachers' professional competencies, while teacher participation also has a meaningful, albeit smaller, impact. The integration of LMS into teacher training programs plays a crucial role in strengthening the professional competencies of pre-service teachers. At the same time, active teacher participation, although less influential, still has a positive impact. These results provide practical implications for policymakers and educators in designing effective training programs. This study highlights the importance of leveraging LMS technology to enhance educational quality and improve teacher training effectiveness.

Keywords: Learning management system, Primary school teacher, Professional Competencies, Adoption Technology, Technology User.

1. Introduction

In modern education, technology has become a key catalyst in transforming teaching and learning methods (Kaimara et al., 2021). Technology significantly influences advancements in the education sector, enabling the development of various educational platforms that facilitate distance learning. One of the increasingly dominant technologies in teacher training is the learning management system (LMS) (Abdul Hamid et al., 2020). As a cornerstone of the education system, teachers are responsible not only for delivering instructional content but also for creating a supportive learning environment, motivating students, and adapting teaching methods to meet individual needs (Marbán & Mulenga, 2019). Primary education serves as the foundation for students' skill and competency development, which will shape their academic and professional trajectories in the future (Sulaiman, 2024). Therefore, teachers play a crucial role in ensuring that the learning process is effective and efficient.

Pre-service teachers, who are in the early stages of their careers, bear a significant responsibility in developing innovative and responsive teaching methods to address students' needs (Tran et al., 2020). Teachers are considered professionals when they have mastered four core competencies: pedagogical competence, personal competence, professional competence, and social competence (Panagiotarou et al., 2020). However, achieving this requires adequate support, both in terms of access to educational resources and relevant training. A conducive learning environment and appropriate technological support play a vital role in helping them grow into competent educators (Olschewski et al., 2023). This is where learning management systems (LMSs) can play a crucial role.

LMS is a highly valuable tool for providing broad and flexible access to high-quality learning resources, with its utilization process facilitated online through LMS support (Wilkinson et al., 2020). LMS offers various features that enable learning to become more flexible, structured, and interactive (Torakulovich, 2024). It is a software platform designed to develop, deliver, and manage courses, learning resources, activities, and assessments (Letsoalo, 2024). However, the effectiveness of an LMS in

enhancing teachers' professional competencies depends not only on the availability of the technology but also on the active participation of pre-service teachers in the learning process. A high level of participation indicates greater engagement and commitment from teachers in utilizing LMS, which, in turn, can improve learning outcomes (ElSayary et al., 2024). Conversely, using an LMS without adequate participation may not yield a significant effect on the enhancement of teachers' professional competencies. Therefore, it is crucial to explore how LMS usage and preservice teacher participation interact to influence their professional competencies.

The Teacher Professional Education Program is an initiative aimed at enhancing and updating educators' knowledge and skills, enabling them to navigate the dynamics and complexities of the education sector (Dindar et al., 2021). By gaining a deeper understanding of how LMSs can support the professional development of preservice teachers, the quality of primary education can be improved, increasing the competence and innovativeness of future teachers. The Preservice Teacher Professional Education Program (PPG Prajabatan) is professionally designed to ensure that preservice teachers are well-prepared to educate with the support of LMSs. LMS allows teachers to design and manage curricula more efficiently, assign tasks and assessments, and monitor student progress in real-time. However, there remains a gap between the training and technical support available and teachers' actual ability to integrate technology into their teaching practices. Many preservice teachers may be unfamiliar with or lack confidence in utilizing technology for instruction, thus requiring adequate training and technical support (Sahal & Ozdemir, 2020). Institutional support is also crucial for the successful implementation of an LMS. School administrations and government bodies must provide supportive policies, funding for technological infrastructure, and continuous professional training for teachers. Therefore, this study aims to explore the effectiveness of LMSs in the professional development of preservice primary school teachers, while also identifying their benefits, challenges, and relevant solutions (Toktarova & Semenova, 2020). Research has sought to examine how LMSs influence various aspects of teaching skill development among prospective teachers.

1.1. LMS use (LU)

The effective use of an LMS is predicted to have a significant effect on enhancing the professional competence of preservice teachers (Sittisak et al., 2022). LMS provides various tools and resources that support the learning process, such as access to educational materials, discussion forums, online assessments, and instant feedback. By utilizing LMSs, preservice teachers can deepen their understanding of pedagogical content, improve their technological skills, and implement more innovative teaching strategies. The professional competencies gained from LMS usage include teaching planning, classroom management, and learning assessment, all of which are key elements in the teaching profession (Umam et al., 2024).

1.2. Teacher Participation (TP)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers. In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

1.3. Professional Teacher Competence (PTC)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers (Flores-Cáceres et al., 2022). In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

2. Method

2.1 Research Design

This study employs a quantitative approach with a questionnaire method to measure the impact of LMS utilization and teacher participation on teachers' professional competence (Dahal & Manandhar, 2024). The research method applied is a structural model, where data are analyzed via statistical software that supports model testing. The variables measured in this study include LMS utilization, teacher participation, and professional competence as latent variables.

2.2 Validity and Reliability Measurement

The validity and reliability of the measurement model (outer model) were tested via several indicators (Rahmi et al., 2024). Convergent validity was assessed by examining the loading factor values of each indicator, where values greater than 0.70 are considered valid (Fadhli et al., 2023). Furthermore, construct reliability was tested via composite reliability (CR) and Cronbach's alpha, with a CR value greater than 0.70 indicating that the latent variable possesses good and consistent reliability. Convergent validity was also evaluated through the average variance extracted (AVE) value, where a value above 0.50 signifies that the indicators exhibit good convergent validity.

2.3 Discriminant validity

Discriminant validity was tested via two methods: the heterotrait-monotrait ratio (HTMT) and the Fornell-Larcker criterion (Sims, 2024). An HTMT value of less than 0.90 indicates good discriminant validity, meaning that indicators measuring a specific variable exhibit greater correlations with items within that variable than with items in other variables. The Fornell-Larcker approach assesses discriminant validity by comparing the square root of the average variance extracted (AVE) with the correlations between latent variables. Discriminant validity is considered fulfilled if the square root of the AVE of a latent variable is greater than its correlation with any other latent variable.

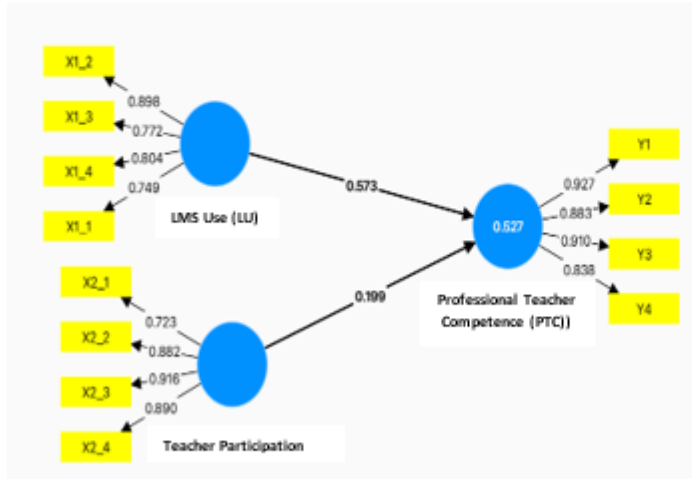
2.4 Multicollinearity Test and Structural Model

To ensure the absence of multicollinearity among variables in the structural model, the variance inflation factor (VIF) values were examined (Kassim, 2024). A VIF value of less than 5 indicates no significant multicollinearity. Following the multicollinearity test, the influence of LMS usage and teacher participation on teacher professional competence was analyzed via the structural model. The magnitude of the influence was assessed on the basis of the path coefficient and f-square values, where a higher f-square value indicates a more significant effect.

3. Results

3.1. Convergent Validity

The path diagram displayed in Smart-PLS illustrates the relationships between LMS utilization, teacher participation, and the professional competence of preservice primary schoolteachers (Wang et al., 2021). In this diagram, LMS utilization is represented by four indicators, each exhibiting a high loading factor, indicating that these indicators strongly reflect the latent variable of LMS utilization. All indicators used in this study have loading factor values above 0.70, demonstrating good convergent validity.



In Figure 1, the X1_2 indicator has a loading factor of 0.898, indicating that this indicator validly measures the LMS Usage variable (Herwin et al., 2022). This suggests that any changes in the LMS Usage variable are significantly reflected in variations

142 in the X1_2 indicator, with a contribution value of 80.6% (0.898×0.898). Overall, all indicators measuring the latent variables
 143 in this study met the criteria for good convergent validity.
 144

145 3.2. Construct Reliability

146 Construct reliability was measured via Cronbach's alpha and composite reliability values. The Cronbach's alpha and
 148 composite reliability (CR) values for each latent variable exceeded 0.70, indicating that these variables are consistent and
 149 reliable in measurement (Santoso et al., 2023).
 150

151 Table 1 Construct reliability

Construct Reliability-Validity	Cronbach Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted
Professional Teacher Competence (PTC)	0.913	0.920	0.938	0.793
Teacher Participation (TP)	0.880	0.918	0.916	0.733
LMS Use (LU)	0.823	0.845	0.882	0.652

152 Table 1 shows that the variable Teacher Professional Competence has a composite reliability value of 0.938, indicating
 153 that the indicators measuring this variable are consistent and reliable. This high CR value suggests that the latent variable in
 154 this study can be trusted to accurately and consistently measure the intended concept.
 155

157 3.3. Discriminant validity

158 Discriminant validity was tested via the heterotrait-monotrait ratio (HTMT) method and the Fornell-Larcker criterion.
 159 Table 2 shows that the HTMT values for each pair of variables are less than 0.90, confirming that discriminant validity has been
 160 achieved (Astuti et al., 2022).
 161

162 Table 2 Discriminant validity (HTMT)

Discriminant Validity (HTMT)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.646		
LMS Use (LU)	0.792	0.782	

164 In other words, the variables in this model exhibit a greater correlation with their own indicators than with the indicators
 165 of other variables, ensuring that each latent construct is truly unique and distinct from the others. Table 3 presents the results
 166 of the Fornell-Larcker analysis, indicating that the square root of the AVE for the professional competence variable is 0.890,
 167 which is greater than its correlation with other variables in the model. This demonstrates that each latent variable possesses
 168 good discriminant validity, meaning that the indicators are more strongly correlated with their respective latent variables than
 169 with other variables (Kusumajati & Chairiyani, 2024).
 170

171 Table 3 Discriminant Validity (Fornell-LC)

Discriminant Validity (Fornell-LC)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)	0.890		
Teacher Participation (TP)	0.599	0.856	
LMS Use (LU)	0.712	0.697	0.808

173 3.4. Influence of LMS Use and Teacher Participation

174 Table 4 Path Coefficients

Path Coefficients- Confidence Interval	Original sample (O)	Sample mean (M)	2.5%	97.5%
Teacher Participation (TP) >>> Professional Teacher Competence (PTC)	0.199	0.203	0.059	0.337
LMS Use (LU) >>> Professional Teacher Competence (PTC)	0.573	0.539		0.722

175

In Table, regarding path coefficients, the use of the learning management system (LMS) is shown to have a significant effect on teacher professional competence, with a path coefficient of 0.573. This finding indicates that an increase in LMS usage significantly enhances Teacher Professional Competence (Yang & Kaiser, 2022). Additionally, Teacher Participation has a significant influence on Teacher Professional Competence, although its effect is smaller, with a path coefficient of 0.199. This suggests that while teacher participation is important, its impact is not as substantial as LMS usage in improving teacher professional competence.

3.5. R-Square

Table 5 R-square

R-square	R-square	R-Square adjusted
Professional Teacher Competence (PTC)	0.527	0.517

Table 5 shows that the R-square value of 52.7% indicates that the model explains 52.7% of the variability in Teacher Professional Competence through LMS usage and Teacher Participation. According to Hair et al., this represents a moderate effect. Additionally, the F-square value illustrates the magnitude of the influence of each independent variable on the dependent variable at the structural level (Wuisan et al., 2023).

3.6. f-square

Table 6 f-square

f-square	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.043		
LMS Use (LU)	0.357		

Table 6 shows that LMS usage has a high impact on Teacher Professional Competence, with an F-Square value of 0.357, whereas Teacher Participation has a low impact, with an F-Square value of 0.043. This confirms that compared with teacher participation, LMS usage is a more dominant factor in determining teacher professional competence (Guillén-Gámez et al., 2023).

4. Discussion(Su & Chen, 2025)

The importance of institutional support, such as favorable policies, funding for technological infrastructure, and continuous training for teachers, is crucial (Hennessy et al., 2022). This support plays a vital role in ensuring the successful implementation of LMSs in teacher training programs. Furthermore, this study highlights that LMS utilization not only provides flexibility in accessing educational resources but also enables personalized learning tailored to individual needs and capabilities (Haddade et al., 2024). The findings indicate that integrating LMSs into teacher training programs significantly contributes to enhancing prospective teachers' professional competencies (Arifin et al., 2023). LMS allows prospective teachers to access various learning resources more flexibly and efficiently while also supporting more personalized learning experiences (Farooq et al., 2014). Other studies have shown that the use of learning management systems (LMS) has a significant positive effect on the quality of teacher competence (Alserhan & Yahaya, 2021). Another study by Runge et al., (2023) also indicated that LMS use plays a role in enhancing teacher competence, where the integration of technology, such as LMSs in learning, influences learning outcomes and is supported by strong teacher competence. The opposite findings suggest that LMS use does not impact teacher competence because of factors such as limitations in online interaction (Annamalai et al., 2021). Another study by (Benjamin Aidoo et al., 2022) also revealed that ICT training for teachers does not impact their ability to conduct online learning. Instead, the training focuses primarily on developing skills to organize and prepare digital teaching materials, rather than enhancing their ability to teach online via an LMS.

The significant impact of LMS use (LU) has practical implications for policymakers and educators in designing effective training programs (Limantara et al., 2023). LMS not only facilitates the teaching and learning process but also supports the professional development of prospective teachers. While teacher participation also has an influence, these findings emphasize the importance of leveraging technology in teacher training and professional development. This study confirms that LMS utilization is a key factor in helping prospective teachers prepare to become competent and professional educators in the

digital era (Elfeky & Elbyaly, 2021). Additionally, adequate institutional support and policies are essential for ensuring the successful implementation of LMSs in teacher training programs (AL-Nuaimi et al., 2022). A study by Rizal et al., (2022) revealed that the role of teachers participating in training significantly influences competency improvement. Through training, teachers become more accustomed to preparing digital teaching materials, which in turn streamlines other instructional processes. Moreover, other studies have reported that the active participation of teachers in training has a positive effect on their competencies. This is because the focus and target of mastering new skills play crucial roles in enhancing the quality of teachers' competencies (de-Torres et al., 2024).

5. Conclusions

Overall, the LMS is a highly effective tool for supporting the education of prospective elementary school teachers, particularly in preparing them to face the challenges of education in the digital era. Effective LMS utilization can enhance interaction, facilitate access to information, and strengthen prospective teachers' pedagogical skills. However, to achieve maximum effectiveness, it is crucial to ensure that the LMS is well integrated into the curriculum and accompanied by adequate training for prospective teachers. The success of an LMS also depends on how well prospective teachers can transfer the skills they acquire into real teaching practices in schools. Therefore, continuous evaluation and improvement of LMS usage are necessary to support educational objectives.

Acknowledgment

We would like to express our deepest gratitude to all the parties who contributed to the writing of this article. We sincerely appreciate the contributions, support, and assistance from various individuals and institutions who have dedicated their time, effort, and valuable insights. Our heartfelt thanks also go to those whose names are not mentioned but have contributed in various ways to the success of this article.

Ethical considerations

Not applicable.

Conflict of interest

The authors declare that they have no conflicts of interest.

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Keywords: learning management system, primary school teacher, professional competencies, adoption technology, technology user.

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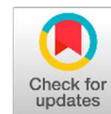
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Effectiveness of Using Learning Management System for Pre-Service Primary School Teachers

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Abstract

The use of Learning Management Systems (LMS) has become an essential tool in the teaching and learning process in education. However, its effectiveness in enhancing the professional competencies of pre-service teachers requires further investigation. This study aims to evaluate the effectiveness of LMS use and teacher participation in developing the professional competencies of pre-service teachers in primary schools. A quantitative research method was employed, utilizing structural model analysis techniques involving 87 pre-service teachers. Data were collected through a questionnaire designed to assess the validity and reliability of the model, as well as to examine the influence of independent variables on the dependent variable. Data analysis was conducted using SmartPLS software, and the results indicated that LMS utilization had a significant and substantial impact on improving teachers' professional competencies. Meanwhile, teacher participation had a lower but still significant effect. The findings demonstrate that LMS usage contributes significantly to the enhancement of teachers' professional competencies, while teacher participation also has a meaningful, albeit smaller, impact. The integration of LMS into teacher training programs plays a crucial role in strengthening the professional competencies of pre-service teachers. At the same time, active teacher participation, although less influential, still has a positive impact. These results provide practical implications for policymakers and educators in designing effective training programs. This study highlights the importance of leveraging LMS technology to enhance educational quality and improve teacher training effectiveness.

Keywords: Learning management system, Primary school teacher, Professional Competencies, Adoption Technology, Technology User.

1. Introduction

In modern education, technology has become a key catalyst in transforming teaching and learning methods (Kaimara et al., 2021). Technology significantly influences advancements in the education sector, enabling the development of various educational platforms that facilitate distance learning. One of the increasingly dominant technologies in teacher training is the learning management system (LMS) (Abdul Hamid et al., 2020). As a cornerstone of the education system, teachers are responsible not only for delivering instructional content but also for creating a supportive learning environment, motivating students, and adapting teaching methods to meet individual needs (Marbán & Mulenga, 2019). Primary education serves as the foundation for students' skill and competency development, which will shape their academic and professional trajectories in the future (Sulaiman, 2024). Therefore, teachers play a crucial role in ensuring that the learning process is effective and efficient.

Pre-service teachers, who are in the early stages of their careers, bear a significant responsibility in developing innovative and responsive teaching methods to address students' needs (Tran et al., 2020). Teachers are considered professionals when they have mastered four core competencies: pedagogical competence, personal competence, professional competence, and social competence (Panagiotarou et al., 2020). However, achieving this requires adequate support, both in terms of access to educational resources and relevant training. A conducive learning environment and appropriate technological support play a vital role in helping them grow into competent educators (Olschewski et al., 2023). This is where learning management systems (LMSs) can play a crucial role.

LMS is a highly valuable tool for providing broad and flexible access to high-quality learning resources, with its utilization process facilitated online through LMS support (Wilkinson et al., 2020). LMS offers various features that enable learning to become more flexible, structured, and interactive (Torakulovich, 2024). It is a software platform designed to develop, deliver, and manage courses, learning resources, activities, and assessments (Letsoalo, 2024). However, the effectiveness of an LMS in



enhancing teachers' professional competencies depends not only on the availability of the technology but also on the active participation of pre-service teachers in the learning process. A high level of participation indicates greater engagement and commitment from teachers in utilizing LMS, which, in turn, can improve learning outcomes (ElSayary et al., 2024). Conversely, using an LMS without adequate participation may not yield a significant effect on the enhancement of teachers' professional competencies. Therefore, it is crucial to explore how LMS usage and preservice teacher participation interact to influence their professional competencies.

The Teacher Professional Education Program is an initiative aimed at enhancing and updating educators' knowledge and skills, enabling them to navigate the dynamics and complexities of the education sector (Dindar et al., 2021). By gaining a deeper understanding of how LMSs can support the professional development of preservice teachers, the quality of primary education can be improved, increasing the competence and innovativeness of future teachers. The Preservice Teacher Professional Education Program (PPG Prajabatan) is professionally designed to ensure that preservice teachers are well-prepared to educate with the support of LMSs. LMS allows teachers to design and manage curricula more efficiently, assign tasks and assessments, and monitor student progress in real-time. However, there remains a gap between the training and technical support available and teachers' actual ability to integrate technology into their teaching practices. Many preservice teachers may be unfamiliar with or lack confidence in utilizing technology for instruction, thus requiring adequate training and technical support (Sahal & Ozdemir, 2020). Institutional support is also crucial for the successful implementation of an LMS. School administrations and government bodies must provide supportive policies, funding for technological infrastructure, and continuous professional training for teachers. Therefore, this study aims to explore the effectiveness of LMSs in the professional development of preservice primary school teachers, while also identifying their benefits, challenges, and relevant solutions (Toktarova & Semenova, 2020). Research has sought to examine how LMSs influence various aspects of teaching skill development among prospective teachers.

1.1. LMS use (LU)

The effective use of an LMS is predicted to have a significant effect on enhancing the professional competence of preservice teachers (Sittisak et al., 2022). LMS provides various tools and resources that support the learning process, such as access to educational materials, discussion forums, online assessments, and instant feedback. By utilizing LMSs, preservice teachers can deepen their understanding of pedagogical content, improve their technological skills, and implement more innovative teaching strategies. The professional competencies gained from LMS usage include teaching planning, classroom management, and learning assessment, all of which are key elements in the teaching profession (Umam et al., 2024).

1.2. Teacher Participation (TP)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers. In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

1.3. Professional Teacher Competence (PTC)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers (Flores-Cáceres et al., 2022). In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

2. Method

2.1 Research Design

This study employs a quantitative approach with a questionnaire method to measure the impact of LMS utilization and teacher participation on teachers' professional competence (Dahal & Manandhar, 2024). The research method applied is a structural model, where data are analyzed via statistical software that supports model testing. The variables measured in this study include LMS utilization, teacher participation, and professional competence as latent variables.

2.2 Validity and Reliability Measurement

The validity and reliability of the measurement model (outer model) were tested via several indicators (Rahmi et al., 2024). Convergent validity was assessed by examining the loading factor values of each indicator, where values greater than 0.70 are considered valid (Fadhli et al., 2023). Furthermore, construct reliability was tested via composite reliability (CR) and Cronbach's alpha, with a CR value greater than 0.70 indicating that the latent variable possesses good and consistent reliability. Convergent validity was also evaluated through the average variance extracted (AVE) value, where a value above 0.50 signifies that the indicators exhibit good convergent validity.

2.3 Discriminant validity

Discriminant validity was tested via two methods: the heterotrait-monotrait ratio (HTMT) and the Fornell-Larcker criterion (Sims, 2024). An HTMT value of less than 0.90 indicates good discriminant validity, meaning that indicators measuring a specific variable exhibit greater correlations with items within that variable than with items in other variables. The Fornell-Larcker approach assesses discriminant validity by comparing the square root of the average variance extracted (AVE) with the correlations between latent variables. Discriminant validity is considered fulfilled if the square root of the AVE of a latent variable is greater than its correlation with any other latent variable.

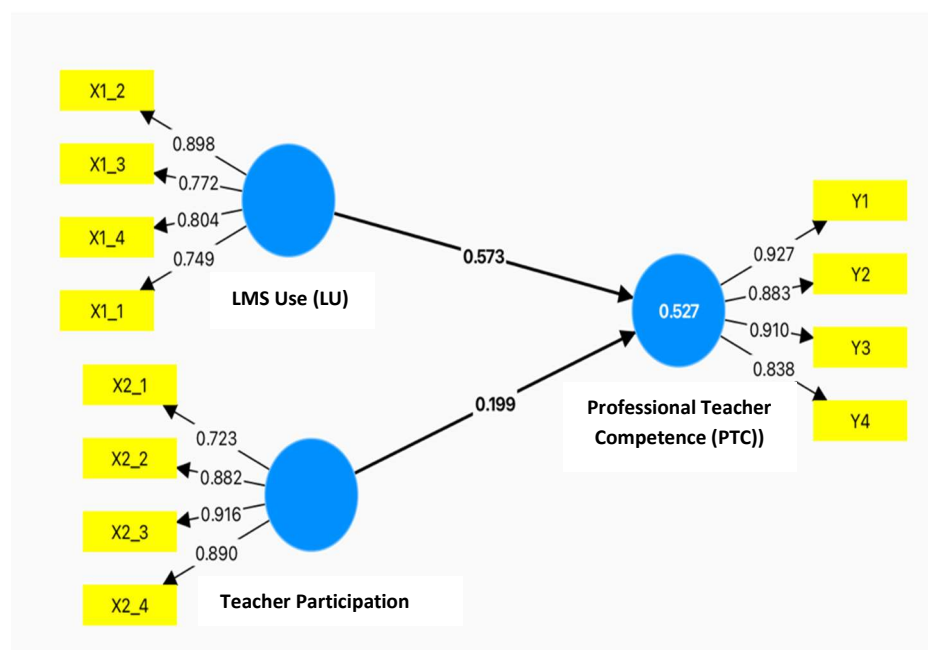
2.4 Multicollinearity Test and Structural Model

To ensure the absence of multicollinearity among variables in the structural model, the variance inflation factor (VIF) values were examined (Kassim, 2024). A VIF value of less than 5 indicates no significant multicollinearity. Following the multicollinearity test, the influence of LMS usage and teacher participation on teacher professional competence was analyzed via the structural model. The magnitude of the influence was assessed on the basis of the path coefficient and f-square values, where a higher f-square value indicates a more significant effect.

3. Results

3.1. Convergent Validity

The path diagram displayed in Smart-PLS illustrates the relationships between LMS utilization, teacher participation, and the professional competence of preservice primary schoolteachers (Wang et al., 2021). In this diagram, LMS utilization is represented by four indicators, each exhibiting a high loading factor, indicating that these indicators strongly reflect the latent variable of LMS utilization. All indicators used in this study have loading factor values above 0.70, demonstrating good convergent validity.



In Figure 1, the X1_2 indicator has a loading factor of 0.898, indicating that this indicator validly measures the LMS Usage variable (Herwin et al., 2022). This suggests that any changes in the LMS Usage variable are significantly reflected in variations

in the X1_2 indicator, with a contribution value of 80.6% (0.898×0.898). Overall, all indicators measuring the latent variables in this study met the criteria for good convergent validity.

3.2. Construct Reliability

Construct reliability was measured via Cronbach's alpha and composite reliability values. The Cronbach's alpha and composite reliability (CR) values for each latent variable exceeded 0.70, indicating that these variables are consistent and reliable in measurement (Santoso et al., 2023).

Table 1 Construct reliability

Construct Reliability-Validity	Cronbach Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted
Professional Teacher Competence (PTC)	0.913	0.920	0.938	0.793
Teacher Participation (TP)	0.880	0.918	0.916	0.733
LMS Use (LU)	0.823	0.845	0.882	0.652

Table 1 shows that the variable Teacher Professional Competence has a composite reliability value of 0.938, indicating that the indicators measuring this variable are consistent and reliable. This high CR value suggests that the latent variable in this study can be trusted to accurately and consistently measure the intended concept.

3.3. Discriminant validity

Discriminant validity was tested via the heterotrait-monotrait ratio (HTMT) method and the Fornell-Larcker criterion. Table 2 shows that the HTMT values for each pair of variables are less than 0.90, confirming that discriminant validity has been achieved (Astuti et al., 2022).

Table 2 Discriminant validity (HTMT)

Discriminant Validity (HTMT)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.646		
LMS Use (LU)	0.792	0.782	

In other words, the variables in this model exhibit a greater correlation with their own indicators than with the indicators of other variables, ensuring that each latent construct is truly unique and distinct from the others. Table 3 presents the results of the Fornell-Larcker analysis, indicating that the square root of the AVE for the professional competence variable is 0.890, which is greater than its correlation with other variables in the model. This demonstrates that each latent variable possesses good discriminant validity, meaning that the indicators are more strongly correlated with their respective latent variables than with other variables (Kusumajati & Chairiyani, 2024).

Table 3 Discriminant Validity (Fornell-LC)

Discriminant Validity (Fornell-LC)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)	0.890		
Teacher Participation (TP)	0.599	0.856	
LMS Use (LU)	0.712	0.697	0.808

3.4. Influence of LMS Use and Teacher Participation

Table 4 Path Coefficients

Path Coefficients- Confidence Interval	Original sample (O)	Sample mean (M)	2.5%	97.5%
Teacher Participation (TP) >>> Professional Teacher Competence (PTC)	0.199	0.203	0.059	0.337
LMS Use (LU) >>> Professional Teacher Competence (PTC)	0.573	0.539		0.722

In Table, regarding path coefficients, the use of the learning management system (LMS) is shown to have a significant effect on teacher professional competence, with a path coefficient of 0.573. This finding indicates that an increase in LMS usage significantly enhances Teacher Professional Competence (Yang & Kaiser, 2022). Additionally, Teacher Participation has a significant influence on Teacher Professional Competence, although its effect is smaller, with a path coefficient of 0.199. This suggests that while teacher participation is important, its impact is not as substantial as LMS usage in improving teacher professional competence.

3.5. R-Square

Table 5 R-square

R-square	R-square	R-Square adjusted
Professional Teacher Competence (PTC)	0.527	0.517

Table 5 shows that the R-square value of 52.7% indicates that the model explains 52.7% of the variability in Teacher Professional Competence through LMS usage and Teacher Participation. According to Hair et al., this represents a moderate effect. Additionally, the F-square value illustrates the magnitude of the influence of each independent variable on the dependent variable at the structural level (Wuisan et al., 2023).

3.6. f-square

Table 6 f-square

f-square	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.043		
LMS Use (LU)	0.357		

Table 6 shows that LMS usage has a high impact on Teacher Professional Competence, with an F-Square value of 0.357, whereas Teacher Participation has a low impact, with an F-Square value of 0.043. This confirms that compared with teacher participation, LMS usage is a more dominant factor in determining teacher professional competence (Guillén-Gámez et al., 2023).

4. Discussion(Su & Chen, 2025)

The importance of institutional support, such as favorable policies, funding for technological infrastructure, and continuous training for teachers, is crucial (Hennessy et al., 2022). This support plays a vital role in ensuring the successful implementation of LMSs in teacher training programs. Furthermore, this study highlights that LMS utilization not only provides flexibility in accessing educational resources but also enables personalized learning tailored to individual needs and capabilities (Haddade et al., 2024). The findings indicate that integrating LMSs into teacher training programs significantly contributes to enhancing prospective teachers' professional competencies (Arifin et al., 2023). LMS allows prospective teachers to access various learning resources more flexibly and efficiently while also supporting more personalized learning experiences (Farooq et al., 2014). Other studies have shown that the use of learning management systems (LMS) has a significant positive effect on the quality of teacher competence (Alserhan & Yahaya, 2021). Another study by Runge et al., (2023) also indicated that LMS use plays a role in enhancing teacher competence, where the integration of technology, such as LMSs in learning, influences learning outcomes and is supported by strong teacher competence. The opposite findings suggest that LMS use does not impact teacher competence because of factors such as limitations in online interaction (Annamalai et al., 2021). Another study by (Benjamin Aidoo et al., 2022) also revealed that ICT training for teachers does not impact their ability to conduct online learning. Instead, the training focuses primarily on developing skills to organize and prepare digital teaching materials, rather than enhancing their ability to teach online via an LMS.

The significant impact of LMS use (LU) has practical implications for policymakers and educators in designing effective training programs (Limantara et al., 2023). LMS not only facilitates the teaching and learning process but also supports the professional development of prospective teachers. While teacher participation also has an influence, these findings emphasize the importance of leveraging technology in teacher training and professional development. This study confirms that LMS utilization is a key factor in helping prospective teachers prepare to become competent and professional educators in the

digital era (Elfeky & Elbyaly, 2021). Additionally, adequate institutional support and policies are essential for ensuring the successful implementation of LMSs in teacher training programs (AL-Nuaimi et al., 2022). A study by Rizal et al., (2022) revealed that the role of teachers participating in training significantly influences competency improvement. Through training, teachers become more accustomed to preparing digital teaching materials, which in turn streamlines other instructional processes. Moreover, other studies have reported that the active participation of teachers in training has a positive effect on their competencies. This is because the focus and target of mastering new skills play crucial roles in enhancing the quality of teachers' competencies (de-Torres et al., 2024).

5. Conclusions

Overall, the LMS is a highly effective tool for supporting the education of prospective elementary school teachers, particularly in preparing them to face the challenges of education in the digital era. Effective LMS utilization can enhance interaction, facilitate access to information, and strengthen prospective teachers' pedagogical skills. However, to achieve maximum effectiveness, it is crucial to ensure that the LMS is well integrated into the curriculum and accompanied by adequate training for prospective teachers. The success of an LMS also depends on how well prospective teachers can transfer the skills they acquire into real teaching practices in schools. Therefore, continuous evaluation and improvement of LMS usage are necessary to support educational objectives.

Acknowledgment

We would like to express our deepest gratitude to all the parties who contributed to the writing of this article. We sincerely appreciate the contributions, support, and assistance from various individuals and institutions who have dedicated their time, effort, and valuable insights. Our heartfelt thanks also go to those whose names are not mentioned but have contributed in various ways to the success of this article.

Ethical considerations

Not applicable.

Conflict of interest

The authors declare that they have no conflicts of interest.

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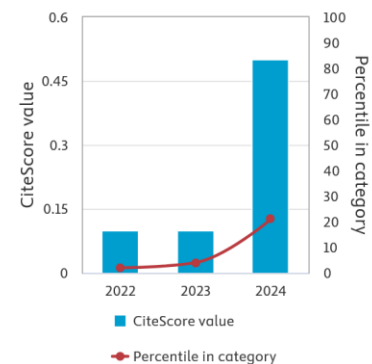
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Effectiveness of Using Learning Management System for Pre-Service Primary School Teachers



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Abstract

The use of Learning Management Systems (LMS) has become an essential tool in the teaching and learning process in education. However, its effectiveness in enhancing the professional competencies of prepre-service teachers requires further investigation. This study aims to evaluate the effectiveness of LMS use and teacher participation in developing the professional competencies of prepre-service teachers in primary schools. A quantitative research method was employed, utilizing structural model analysis techniques involving 87 prepre-service teachers. Data were collected through a questionnaire designed to assess the validity and reliability of the model, as well as to examine the influence of independent variables on the dependent variable. Data analysis was conducted using SmartPLS software, and the results indicated that LMS utilization had a significant and substantial impact on improving teachers' professional competencies. Meanwhile, teacher participation had a lower but still significant effect. The findings demonstrate that LMS usage contributes significantly to the enhancement of teachers' professional competencies, while teacher participation also has a meaningful, albeit smaller, impact. The integration of LMS into teacher training programs plays a crucial role in strengthening the professional competencies of prepre-service teachers. At the same time, active teacher participation, although less influential, still has a positive impact. These results provide practical implications for policymakers and educators in designing effective training programs. This study highlights the importance of leveraging LMS technology to enhance educational quality and improve teacher training effectiveness.

Keywords: Learning management system, Primary school teacher, Professional Competencies, Adoption Technology, Technology User.

1. Introduction

In modern education, technology has become a key catalyst in transforming teaching and learning methods (Kaimara et al., 2021). Technology significantly influences advancements in the education sector, enabling the development of various educational platforms that facilitate distance learning. One of the increasingly dominant technologies in teacher training is the Learning-Management-Systemlearning management system (LMS) (Abdul Hamid et al., 2020). As a cornerstone of the education system, teachers are responsible not only for delivering instructional content but also for creating a supportive learning environment, motivating students, and adapting teaching methods to meet individual needs (Marbán & Mulenga, 2019). Primary education serves as the foundation for students' skill and competency development, which will shape their academic and professional trajectories in the future (Sulaiman, 2024). Therefore, teachers play a crucial role in ensuring that the learning process is effective and efficient.

PrePre-service teachers, who are in the early stages of their careers, bear a significant responsibility in developing innovative and responsive teaching methods to address students' needs (Tran et al., 2020). Teachers are considered professionals when they have mastered four core competencies: pedagogical competence, personal competence, professional competence, and social competence (Panagiotarou et al., 2020). However, achieving this requires adequate support, both in terms of access to educational resources and relevant training. A conducive learning environment and appropriate technological support play a vital role in helping them grow into competent educators (Olschewski et al., 2023). This is where Learning-Management-Systemslearning management systems (LMSs) can play a crucial role.

LMS is a highly valuable tool for providing broad and flexible access to high-quality learning resources, with its utilization process facilitated online through LMS support (Wilkinson et al., 2020). LMS offers various features that enable learning to become more flexible, structured, and interactive (Torakulovich, 2024). It is a software platform designed to develop, deliver, and manage courses, learning resources, activities, and assessments (Letsoalo, 2024). However, the

effectiveness of [an LMS](#) in enhancing teachers' professional competencies ~~does depends~~ not ~~solely depend on~~ on the availability of the technology but also on the active participation of [prepre-service](#) teachers in the learning process. A high level of participation indicates greater engagement and commitment from teachers in utilizing LMS, which, in turn, can improve learning outcomes (ElSayary et al., 2024). Conversely, using [an LMS](#) without adequate participation may not yield a significant ~~impac~~[impac](#)effect on the enhancement of teachers' professional competencies. Therefore, it is crucial to explore how LMS usage and [pre-servicepreservice](#) teacher participation interact to influence their professional competencies.

The Teacher Professional Education Program is an initiative aimed at enhancing and updating educators' knowledge and skills, enabling them to navigate the dynamics and complexities of the education sector (Dindar et al., 2021). By gaining a deeper understanding of how [LMSLMSs](#) can support the professional development of [prepre-service](#) teachers, ~~it is expected~~ [that the quality of primary education can be improved, preparing future teachers to be more competent and innovative. The Pre-serviceIncreasing the competence and innovativeness of future teachers. The Preservice](#) Teacher Professional Education Program (PPG Prajabatan) is professionally designed to ensure that [pre-servicepreservice](#) teachers are well-prepared to educate with the support of [LMSLMSs](#). LMS allows teachers to design and manage curricula more efficiently, assign tasks and assessments, and monitor student progress in real-time. However, there remains a gap between the training and technical support available and teachers' actual ability to integrate technology into their teaching practices. Many [prepre-service](#) teachers may be unfamiliar with or lack confidence in utilizing technology for instruction, thus requiring adequate training and technical support (Sahal & Ozdemir, 2020). Institutional support is also crucial for the successful implementation of [an LMS](#). School administrations and government bodies must provide supportive policies, funding for technological infrastructure, and continuous professional training for teachers. Therefore, this study aims to explore the effectiveness of [LMSLMSs](#) in the professional development of [prepre-service](#) primary school teachers, while also identifying ~~its~~[their](#) benefits, challenges, and relevant solutions (Toktarova & Semenova, 2020). ~~The research seeks~~[Research has sought](#) to examine how [LMS influencesLMSs influence](#) various aspects of teaching skill development among prospective teachers.

1.1. LMS Useuse (LU)

The effective use of [an LMS](#) is predicted to have a significant ~~impac~~[impac](#)effect on enhancing the professional competence of [prepre-service](#) teachers (Sittisak et al., 2022). LMS provides various tools and resources that support the learning process, such as access to educational materials, discussion forums, online assessments, and instant feedback. By utilizing [LMS, pre-serviceLMSs, preservice](#) teachers can deepen their understanding of pedagogical content, improve ~~their~~[their](#) technological skills, and implement more innovative teaching strategies. The professional competencies gained from LMS usage include teaching planning, classroom management, and learning assessment, all of which are key elements in the teaching profession (Umam et al., 2024).

1.2. Teacher Participation (TP)

The active participation of [prepre-service](#) teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where [prepre-service](#) teachers not only receive information but also actively interact with content and peers. In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, [prepre-service](#) teachers' participation in [LMSLMSs](#) will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

1.3. Professional Teacher Competence (PTC)

The active participation of [prepre-service](#) teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where [prepre-service](#) teachers not only receive information but also actively interact with content and peers (Flores-Cáceres et al., 2022). In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, [prepre-service](#) teachers' participation in [LMSLMSs](#) will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

2. Method

2.1 Research Design

This study employs a quantitative approach [usingwith](#) a questionnaire method to measure the impact of LMS utilization and teacher participation on teachers' professional competence (Dahal & Manandhar, 2024). The research method applied is a structural model, where data ~~isare~~[isare](#) analyzed [usingvia](#) statistical software that supports model testing. The

variables measured in this study include LMS utilization, teacher participation, and professional competence as latent variables.

2.2 Validity and Reliability Measurement

The validity and reliability of the measurement model (outer model) were tested using several indicators (Rahmi et al., 2024). Convergent validity was assessed by examining the loading factor values of each indicator, where values greater than 0.70 are considered valid (Fadhli et al., 2023). Furthermore, construct reliability was tested using Composite Reliability (CR) and Cronbach's Alpha, with a CR value greater than 0.70 indicating that the latent variable possesses good and consistent reliability. Convergent validity was also evaluated through the Average Variance Extracted (AVE) value, where a value above 0.50 signifies that the indicators exhibit good convergent validity.

2.3 Discriminant Validity

Discriminant validity was tested using two methods: the Heterotrait-Monotrait Ratio (HTMT) and the Fornell-Larcker criterion (Sims, 2024). An HTMT value of less than 0.90 indicates good discriminant validity, meaning that indicators measuring a specific variable exhibit higher correlations with items within that variable compared to items in other variables. The Fornell-Larcker approach assesses discriminant validity by comparing the square root of the Average Variance Extracted (AVE) with the correlations between latent variables. Discriminant validity is considered fulfilled if the square root of the AVE of a latent variable is greater than its correlation with any other latent variable.

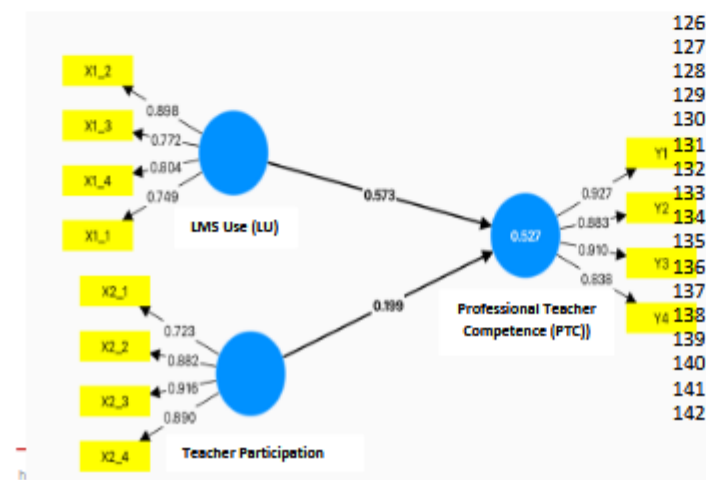
2.4 Multicollinearity Test and Structural Model

To ensure the absence of multicollinearity among variables in the structural model, the Variance-Inflated Factor (VIF) values were examined (Kassim, 2024). A VIF value of less than 5 indicates no significant multicollinearity. Following the multicollinearity test, the influence of LMS Usage and Teacher Participation on Teacher Professional Competence was analyzed via the structural model. The magnitude of the influence was assessed based on the path coefficient and f-square values, where a higher f-square value indicates a more significant effect.

3. Results

3.1 Convergent Validity

The path diagram displayed in Smart-PLS illustrates the relationships between LMS utilization, teacher participation, and the professional competence of pre-service primary school teachers (Wang et al., 2021). In this diagram, LMS utilization is represented by four indicators, each exhibiting a high loading factor, indicating that these indicators strongly reflect the latent variable of LMS utilization. All indicators used in this study have loading factor values above 0.70, demonstrating good convergent validity.



In Figure 1, the X1_2 Indicator has a loading factor of 0.898, indicating that this Indicator validly measures the LMS Usage variable (Herwin et al., 2022). This suggests that any changes in the LMS Usage variable are significantly reflected in variations in the X1_2 Indicator, with a contribution value of 80.6% ($0.898^2 \times 0.898$). Overall, all indicators measuring the latent variables in this study have met the criteria for good convergent validity.

3.2. Construct Reliability

Construct reliability was measured using Cronbach's Alpha and Composite Reliability values. The Cronbach's Alpha and Composite Reliability (CR) values for each latent variable exceeded 0.70, indicating that these variables are consistent and reliable in measurement (Santoso et al., 2023).

Table 1 Construct Reliability

Construct Reliability-Validity	Cronbach Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted
Professional Teacher Competence (PTC)	0.913	0.920	0.938	0.793
Teacher Participation (TP)	0.880	0.918	0.916	0.733
LMS Use (LU)	0.823	0.845	0.882	0.652

In Table 1 shows that the variable Teacher Professional Competence has a Composite Reliability value of 0.938, indicating that the indicators measuring this variable are consistent and reliable. This high CR value suggests that the latent variable in this study can be trusted to accurately and consistently measure the intended concept.

3.3. Discriminant Validity

Discriminant validity was tested using the Heterotrait-Monotrait Ratio (HTMT) method and the Fornell-Larcker criterion. In the table 2 show analysis results indicate Table 2 shows that the HTMT values for each pair of variables are less than 0.90, confirming that discriminant validity has been achieved (Astuti et al., 2022).

Table 2 Discriminant Validity (HTMT)

Discriminant Validity (HTMT)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.646		
LMS Use (LU)	0.792	0.782	

In other words, the variables in this model exhibit a higher correlation with their own indicators than with the indicators of other variables, ensuring that each latent construct is truly unique and distinct from the others. Table 3 presents the results of the Fornell-Larcker analysis, indicating that the square root of the AVE for the Professional Competence variable is 0.890, which is greater than its correlation with other variables in the model. This demonstrates that each latent variable possesses good discriminant validity, meaning that the indicators are more strongly correlated with their respective latent variables than with other variables (Kusumajati & Chairyani, 2024).

Table 3 Discriminant Validity (Fornell-LC)

Discriminant Validity (Fornell-LC)	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)	0.890		
Teacher Participation (TP)	0.599	0.856	
LMS Use (LU)	0.712	0.697	0.808

3.4. The Influence of LMS Use and Teacher Participation

Table 4 Path Coefficients

Path Coefficients- Confidence Interval	Original sample (O)	Sample mean (M)	2.5%	97.5%
Teacher Participation (TP) >>> Professional Teacher Competence (PTC)	0.199	0.203	0.059	0.337
LMS Use (LU) >>> Professional Teacher Competence (PTC)	0.573	0.539		0.722

In [tableTable 4-on, regarding](#) path coefficients, the use of the [Learning Management Systemlearning management system](#) (LMS) is shown to have a significant [impac effect](#) on [Teacher Professional Competenceteacher professional competence](#), with a path coefficient of 0.573. This [finding](#) indicates that an increase in LMS usage [will significantly enhanceenhances](#) Teacher Professional Competence (Yang & Kaiser, 2022). Additionally, Teacher Participation [also](#) has a significant influence on Teacher Professional Competence, although its effect is smaller, with a path coefficient of 0.199. This suggests that while teacher participation is important, its impact is not as substantial as LMS usage in improving teacher professional competence.

3.5. R-Square

Table 5 R-square

R-square	R-square	R-Square adjusted
Professional Teacher Competence (PTC)	0.527	0.517

Table 5 shows that the [R-Squaresquare](#) value of 52.7% indicates that the model explains 52.7% of the variability in Teacher Professional Competence through LMS usage and Teacher Participation. According to Hair et al., this represents a moderate effect. Additionally, the [F-Squaresquare](#) value illustrates the magnitude of the influence of each independent variable on the dependent variable at the structural level (Wulsan et al., 2023).

3.6. f-square

Table 6 f-square

f-square	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.043		
LMS Use (LU)	0.357		

Table 6 shows that LMS usage has a high impact on Teacher Professional Competence, with an F-Square value of 0.357, whereas Teacher Participation has a low impact, with an F-Square value of 0.043. This confirms that [compared with teacher participation](#), LMS usage is a more dominant factor in determining [Teacher Professional Competence-compared to teacher-participationteacher professional competence](#) (Guillén-Gámez et al., 2023).

4. Discussion(Su & Chen, 2025)

The importance of institutional support, such as favorable policies, funding for technological infrastructure, and continuous training for teachers, is crucial (Hennessy et al., 2022). This support plays a vital role in ensuring the successful implementation of [LMSLMSs](#) in teacher training programs. Furthermore, this study highlights that LMS utilization not only provides flexibility in accessing educational resources but also enables personalized learning tailored to individual needs and capabilities (Haddade et al., 2024). The findings indicate that integrating [LMSLMSs](#) into teacher training programs significantly contributes to enhancing prospective teachers' professional competencies (Arifin et al., 2023). LMS allows prospective teachers to access various learning resources more flexibly and efficiently while also supporting more personalized learning experiences (Farooq et al., 2014). Other studies have [foundshown](#) that the use of [Learning Management Systems\(LMS-Uselearning management systems \(LMS\)](#) has a significant positive [impac effect](#) on the quality of

teacher competence (Alserhan & Yahaya, 2021). Another study by Runge et al., (2023) also ~~indicates~~[indicated](#) that LMS use plays a role in enhancing teacher competence, where the integration of technology, such as ~~LMS~~[LMSs](#) in learning, influences learning outcomes and is supported by strong teacher competence. The opposite findings suggest that LMS use does not impact teacher competence ~~due to~~[because of](#) factors such as limitations in online interaction (Annamalai et al., 2021). Another study by (Benjamin Aldoo et al., 2022) also ~~found~~[revealed](#) that ICT training for teachers does not impact their ability to conduct online learning. Instead, the training ~~primarily~~[focuses primarily](#) on developing skills to organize and prepare digital teaching materials, rather than enhancing their ability to teach online ~~using~~[via](#) an LMS.

The significant impact of LMS ~~Use~~[use](#) (LU) has practical implications for policymakers and educators in designing effective training programs (Umantara et al., 2023). LMS not only facilitates the teaching and learning process but also supports the professional development of prospective teachers. While teacher participation also has an influence, these findings emphasize the importance of leveraging technology in teacher training and professional development. This study confirms that LMS utilization is a key factor in helping prospective teachers prepare to become competent and professional educators in the digital era (Elfeky & Elbyaly, 2021). Additionally, adequate institutional support and policies are essential ~~to~~[for](#) ensuring the successful implementation of ~~LMS~~[LMSs](#) in teacher training programs (AL-Nuaimi et al., 2022). ~~The~~[A](#) study by Rizal et al., (2022) ~~found~~[revealed](#) that the role of teachers participating in training significantly influences competency improvement. Through training, teachers become more accustomed to preparing digital teaching materials, which in turn streamlines other instructional processes. ~~Meanwhile~~[Moreover](#), other studies have ~~also found~~[reported](#) that the active participation of teachers in training has a positive ~~impact~~[effect](#) on their competencies. This is because the focus and target of mastering new skills play ~~a~~[crucial](#) ~~role~~[roles](#) in enhancing the quality of teachers' competencies (de-Torres et al., 2024).

5. Conclusions

Overall, ~~the~~[LMS](#) is a highly effective tool ~~in~~[for](#) supporting the education of prospective elementary school teachers, particularly in preparing them to face the challenges of education in the digital era. Effective LMS utilization can enhance interaction, facilitate access to information, and strengthen prospective teachers' pedagogical skills. However, to achieve maximum effectiveness, it is crucial to ensure that ~~the~~[LMS](#) is well integrated into the curriculum and accompanied by adequate training for prospective teachers. The success of ~~an~~[LMS](#) also depends on how well prospective teachers can transfer the skills they acquire into real teaching practices in schools. Therefore, continuous evaluation and improvement of LMS usage are necessary to ~~holistically~~[support](#) educational objectives.

Acknowledgment

We would like to express our deepest gratitude to all ~~the~~[parties](#) who ~~have~~[contributed](#) to the writing of this article. We sincerely appreciate the contributions, support, and assistance from various individuals and institutions who have dedicated their time, effort, and valuable insights. Our heartfelt thanks also go to those whose names are not mentioned but have contributed in various ways to the success of this article.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare ~~that they have~~[no](#) conflicts of interest.

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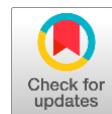
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Effectiveness of using learning management system for pre-service primary school teachers



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Abstract The integration of Learning Management Systems (LMS) has become a critical component of educational processes, particularly in facilitating technology-enhanced learning. LMS plays a pivotal role in supporting digital instruction, especially for prospective professional teachers who are expected to develop proficiency in utilizing such technologies. Nevertheless, the effectiveness of LMS in enhancing the professional competencies of future teachers remains an area requiring further empirical investigation. This study aims to evaluate the impact of LMS utilization and teacher participation on the development of professional competencies among prospective elementary school teachers in Indonesia. A quantitative research design was employed, utilizing structural equation modeling (SEM) techniques with a sample of 87 pre-service elementary school teachers. Data were collected via a structured questionnaire distributed through Google Forms, designed to assess both the validity and reliability of the measurement model and to examine the influence of independent variables on the dependent variable. Data analysis was conducted using SmartPLS software. The results indicate that LMS usage has a significant and substantial effect on the enhancement of teachers' professional competencies. In contrast, teacher participation, while showing a statistically significant influence, had a comparatively smaller effect size. These findings suggest that LMS integration substantially contributes to the development of professional competencies in teacher training, while active participation by teachers also exerts a meaningful, albeit more limited, influence. The study underscores the strategic importance of embedding LMS platforms in teacher education programs to strengthen professional capabilities. Furthermore, the findings provide practical implications for policymakers and educators in designing effective, technology-driven training frameworks. Ultimately, this research highlights the value of leveraging LMS technologies to improve the quality and effectiveness of teacher education.

Keywords: learning management system, primary school teacher, professional competencies, adoption technology, technology user

1. Introduction

In modern education, technology has become a key catalyst in transforming teaching and learning methods (Kaimara et al., 2021). Technology significantly influences advancements in the education sector, enabling the development of various educational platforms that facilitate distance learning. One of the increasingly dominant technologies in teacher training is the learning management system (LMS) (Abdul Hamid et al., 2020). As a cornerstone of the education system, teachers are responsible not only for delivering instructional content but also for creating a supportive learning environment, motivating students, and adapting teaching methods to meet individual needs (Marbán & Mulenga, 2019). Primary education serves as the foundation for students' skill and competency development, which will shape their academic and professional trajectories in the future (Sulaiman, 2024). Therefore, teachers play a crucial role in ensuring that the learning process is effective and efficient.

Pre-service teachers, who are in the early stages of their careers, bear a significant responsibility in developing innovative and responsive teaching methods to address students' needs (Tran et al., 2020). Teachers are considered professionals when they have mastered four core competencies: pedagogical competence, personal competence, professional competence, and social competence (Panagiotarou et al., 2020). However, achieving this requires adequate support, both in terms of access to educational resources and relevant training. A conducive learning environment and appropriate technological support play a vital role in helping them grow into competent educators (Olschewski et al., 2023). This is where learning management systems (LMSs) can play a crucial role.

LMS is a highly valuable tool for providing broad and flexible access to high-quality learning resources, with its utilization process facilitated online through LMS support (Wilkinson et al., 2020). LMS offers various features that enable learning to become more flexible, structured, and interactive (Torakulovich, 2024). It is a software platform designed to develop, deliver,



and manage courses, learning resources, activities, and assessments (Letsoalo, 2024). However, the effectiveness of an LMS in enhancing teachers' professional competencies depends not only on the availability of the technology but also on the active participation of pre-service teachers in the learning process. A high level of participation indicates greater engagement and commitment from teachers in utilizing LMS, which, in turn, can improve learning outcomes (ElSayary et al., 2024). Conversely, using an LMS without adequate participation may not yield a significant effect on the enhancement of teachers' professional competencies. Therefore, it is crucial to explore how LMS usage and preservice teacher participation interact to influence their professional competencies.

The Teacher Professional Education Program is an initiative aimed at enhancing and updating educators' knowledge and skills, enabling them to navigate the dynamics and complexities of the education sector (Dindar et al., 2021). By gaining a deeper understanding of how LMSs can support the professional development of preservice teachers, the quality of primary education can be improved, increasing the competence and innovativeness of future teachers. The Preservice Teacher Professional Education Program (PPG Prajabatan) is professionally designed to ensure that preservice teachers are well-prepared to educate with the support of LMSs. LMS allows teachers to design and manage curricula more efficiently, assign tasks and assessments, and monitor student progress in real-time. However, there remains a gap between the training and technical support available and teachers' actual ability to integrate technology into their teaching practices. Many preservice teachers may be unfamiliar with or lack confidence in utilizing technology for instruction, thus requiring adequate training and technical support (Sahal & Ozdemir, 2020). Institutional support is also crucial for the successful implementation of an LMS. School administrations and government bodies must provide supportive policies, funding for technological infrastructure, and continuous professional training for teachers. Therefore, this study aims to explore the effectiveness of LMSs in the professional development of preservice primary school teachers, while also identifying their benefits, challenges, and relevant solutions (Toktarova & Semenova, 2020). Research has sought to examine how LMSs influence various aspects of teaching skill development among prospective teachers.

1.1. LMS use (LU)

The effective use of an LMS is predicted to have a significant effect on enhancing the professional competence of preservice teachers (Sittisak et al., 2022). LMS provides various tools and resources that support the learning process, such as access to educational materials, discussion forums, online assessments, and instant feedback. By utilizing LMSs, preservice teachers can deepen their understanding of pedagogical content, improve their technological skills, and implement more innovative teaching strategies. The professional competencies gained from LMS usage include teaching planning, classroom management, and learning assessment, all of which are key elements in the teaching profession (Umam et al., 2024).

1.2. Teacher Participation (TP)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers. In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

1.3. Professional Teacher Competence (PTC)

The active participation of preservice teachers in learning activities provided by the LMS is expected to serve as a significant mediating variable in the relationship between LMS usage and teachers' professional competence. High participation reflects deep engagement in the learning process, where preservice teachers not only receive information but also actively interact with content and peers (Flores-Cáceres et al., 2022). In other words, while LMS usage is important, active participation is the key to maximizing the benefits of this system. Therefore, preservice teachers' participation in LMSs will mediate and strengthen the relationship between LMS usage and the enhancement of teachers' professional competence.

2. Method

2.1. Research Design

This study employs a quantitative approach with a questionnaire method to measure the impact of LMS utilization and teacher participation on teachers' professional competence (Dahal & Manandhar, 2024). The research method applied is a structural model, where data are analyzed via statistical software that supports model testing. The variables measured in this study include LMS utilization, teacher participation, and professional competence as latent variables.

2.2. Validity and Reliability Measurement

The validity and reliability of the measurement model (outer model) were tested via several indicators (Rahmi et al., 2024). Convergent validity was assessed by examining the loading factor values of each indicator, where values greater than 0.70 are considered valid (Fadhli et al., 2023). Furthermore, construct reliability was tested via composite reliability (CR) and Cronbach's alpha, with a CR value greater than 0.70 indicating that the latent variable possesses good and consistent reliability. Convergent validity was also evaluated through the average variance extracted (AVE) value, where a value above 0.50 signifies that the indicators exhibit good convergent validity.

2.3. Discriminant validity

Discriminant validity was tested via two methods: the heterotrait-monotrait ratio (HTMT) and the Fornell-Larcker criterion (Sims, 2024). An HTMT value of less than 0.90 indicates good discriminant validity, meaning that indicators measuring a specific variable exhibit greater correlations with items within that variable than with items in other variables. The Fornell-Larcker approach assesses discriminant validity by comparing the square root of the average variance extracted (AVE) with the correlations between latent variables. Discriminant validity is considered fulfilled if the square root of the AVE of a latent variable is greater than its correlation with any other latent variable.

2.4. Multicollinearity Test and Structural Model

To ensure the absence of multicollinearity among variables in the structural model, the variance inflation factor (VIF) values were examined (Kassim, 2024). A VIF value of less than 5 indicates no significant multicollinearity. Following the multicollinearity test, the influence of LMS usage and teacher participation on teacher professional competence was analyzed via the structural model. The magnitude of the influence was assessed on the basis of the path coefficient and f-square values, where a higher f-square value indicates a more significant effect.

3. Results

3.1. Convergent Validity

The path diagram displayed in Smart-PLS illustrates the relationships between LMS utilization, teacher participation, and the professional competence of preservice primary schoolteachers (Wang et al., 2021). In this diagram, LMS utilization is represented by four indicators, each exhibiting a high loading factor, indicating that these indicators strongly reflect the latent variable of LMS utilization. All indicators used in this study have loading factor values above 0.70, demonstrating good convergent validity.

In Figure 1, the X1_2 indicator has a loading factor of 0.898, indicating that this indicator validly measures the LMS Usage variable (Herwin et al., 2022). This suggests that any changes in the LMS Usage variable are significantly reflected in variations in the X1_2 indicator, with a contribution value of 80.6% (0.898×0.898). Overall, all indicators measuring the latent variables in this study met the criteria for good convergent validity.

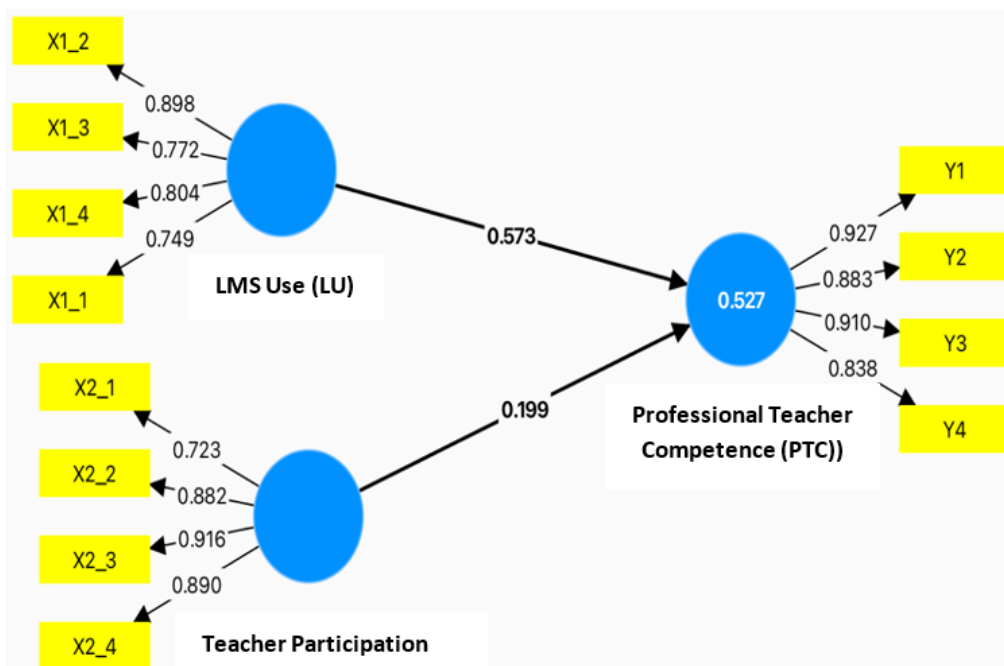


Figure 1 Outer Loading Model.

3.2. Construct Reliability

Construct reliability was measured via Cronbach's alpha and composite reliability values. The Cronbach's alpha and composite reliability (CR) values for each latent variable exceeded 0.70, indicating that these variables are consistent and reliable in measurement (Santoso et al., 2023).

Table 1 shows that the variable Teacher Professional Competence has a composite reliability value of 0.938, indicating that the indicators measuring this variable are consistent and reliable. This high CR value suggests that the latent variable in this study can be trusted to accurately and consistently measure the intended concept.

Table 1 Construct reliability.

Construct Reliability-Validity				
	Cronbach Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted
Professional Teacher Competence (PTC)	0.913	0.920	0.938	0.793
Teacher Participation (TP)	0.880	0.918	0.916	0.733
LMS Use (LU)	0.823	0.845	0.882	0.652

3.3. Discriminant validity

Discriminant validity was tested via the heterotrait-monotrait ratio (HTMT) method and the Fornell-Larcker criterion. Table 2 shows that the HTMT values for each pair of variables are less than 0.90, confirming that discriminant validity has been achieved (Astuti et al., 2022).

Table 2 Discriminant validity (HTMT).

Discriminant Validity (HTMT)			
	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.646		
LMS Use (LU)	0.792	0.782	

In other words, the variables in this model exhibit a greater correlation with their own indicators than with the indicators of other variables, ensuring that each latent construct is truly unique and distinct from the others. Table 3 presents the results of the Fornell-Larcker analysis, indicating that the square root of the AVE for the professional competence variable is 0.890, which is greater than its correlation with other variables in the model. This demonstrates that each latent variable possesses good discriminant validity, meaning that the indicators are more strongly correlated with their respective latent variables than with other variables (Kusumajati & Chairiyani, 2024).

Table 3 Discriminant Validity (Fornell-LC).

Discriminant Validity (Fornell-LC)			
	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)	0.890		
Teacher Participation (TP)	0.599	0.856	
LMS Use (LU)	0.712	0.697	0.808

3.4. Influence of LMS Use and Teacher Participation

In Table 4, regarding path coefficients, the use of the learning management system (LMS) is shown to have a significant effect on teacher professional competence, with a path coefficient of 0.573. This finding indicates that an increase in LMS usage significantly enhances Teacher Professional Competence (Yang & Kaiser, 2022). Additionally, Teacher Participation has a significant influence on Teacher Professional Competence, although its effect is smaller, with a path coefficient of 0.199. This suggests that while teacher participation is important, its impact is not as substantial as LMS usage in improving teacher professional competence.

Table 4 Path Coefficients.

Path Coefficients- Confidence Interval					
	Original sample (O)	Sample mean (M)	2.5%	97.5%	
Teacher Participation (TP) >>> Professional Teacher Competence (PTC)	0.199	0.203	0.059	0.337	
LMS Use (LU) >>> Professional Teacher Competence (PTC)	0.573	0.539		0.722	

3.5. R-Square

Table 5 shows that the R-square value of 52.7% indicates that the model explains 52.7% of the variability in Teacher Professional Competence through LMS usage and Teacher Participation. According to Hair et al., this represents a moderate effect. Additionally, the F-square value illustrates the magnitude of the influence of each independent variable on the dependent variable at the structural level (Wuisan et al., 2023).

Table 5 R-square.

R-square		
	R-square	R-Square adjusted
Professional Teacher Competence (PTC)	0.527	0.517

3.6. f-square

Table 6 shows that LMS usage has a high impact on Teacher Professional Competence, with an F-Square value of 0.357, whereas Teacher Participation has a low impact, with an F-Square value of 0.043. This confirms that compared with teacher participation, LMS usage is a more dominant factor in determining teacher professional competence (Guillén-Gámez et al., 2023).

Table 6 f-square.

f-square			
	Professional Teacher Competence (PTC)	Teacher Participation (TP)	LMS Use (LU)
Professional Teacher Competence (PTC)			
Teacher Participation (TP)	0.043		
LMS Use (LU)	0.357		

4. Discussion

The importance of institutional support, such as favorable policies, funding for technological infrastructure, and continuous training for teachers, is crucial (Hennessy et al., 2022). This support plays a vital role in ensuring the successful implementation of LMSs in teacher training programs. Furthermore, this study highlights that LMS utilization not only provides flexibility in accessing educational resources but also enables personalized learning tailored to individual needs and capabilities (Haddade et al., 2024). The findings indicate that integrating LMSs into teacher training programs significantly contributes to enhancing prospective teachers' professional competencies (Arifin et al., 2023). LMS allows prospective teachers to access various learning resources more flexibly and efficiently while also supporting more personalized learning experiences (Farooq et al., 2014). Other studies have shown that the use of learning management systems (LMS) has a significant positive effect on the quality of teacher competence (Alserhan & Yahaya, 2021). Another study by Runge et al., (2023) also indicated that LMS use plays a role in enhancing teacher competence, where the integration of technology, such as LMSs in learning, influences learning outcomes and is supported by strong teacher competence. The opposite findings suggest that LMS use does not impact teacher competence because of factors such as limitations in online interaction (Annamalai et al., 2021). Another study by (Benjamin Aidoo et al., 2022) also revealed that ICT training for teachers does not impact their ability to conduct online learning. Instead, the training focuses primarily on developing skills to organize and prepare digital teaching materials, rather than enhancing their ability to teach online via an LMS.

The significant impact of LMS use (LU) has practical implications for policymakers and educators in designing effective training programs (Limantara et al., 2023). LMS not only facilitates the teaching and learning process but also supports the professional development of prospective teachers. While teacher participation also has an influence, these findings emphasize the importance of leveraging technology in teacher training and professional development. This study confirms that LMS utilization is a key factor in helping prospective teachers prepare to become competent and professional educators in the digital era (Elfeky & Elbaly, 2021). Additionally, adequate institutional support and policies are essential for ensuring the successful implementation of LMSs in teacher training programs (AL-Nuaimi et al., 2022). A study by Rizal et al., (2022) revealed that the role of teachers participating in training significantly influences competency improvement. Through training, teachers become more accustomed to preparing digital teaching materials, which in turn streamlines other instructional processes. Moreover, other studies have reported that the active participation of teachers in training has a positive effect on their competencies. This is because the focus and target of mastering new skills play crucial roles in enhancing the quality of teachers' competencies (de-Torres et al., 2024).

5. Conclusions

Overall, the LMS is a highly effective tool for supporting the education of prospective elementary school teachers, particularly in preparing them to face the challenges of education in the digital era. Effective LMS utilization can enhance interaction, facilitate access to information, and strengthen prospective teachers' pedagogical skills. However, to achieve maximum effectiveness, it is crucial to ensure that the LMS is well integrated into the curriculum and accompanied by adequate

training for prospective teachers. The success of an LMS also depends on how well prospective teachers can transfer the skills they acquire into real teaching practices in schools. Therefore, continuous evaluation and improvement of LMS usage are necessary to support educational objectives.

Acknowledgment

We would like to express our deepest gratitude to all the parties who contributed to the writing of this article. We sincerely appreciate the contributions, support, and assistance from various individuals and institutions who have dedicated their time, effort, and valuable insights. Our heartfelt thanks also go to those whose names are not mentioned but have contributed in various ways to the success of this article.

Ethical considerations

We confirm that we have obtained all consent required by the applicable law to publish any personal details or images of patients, research subjects, or other individuals used. We agree to provide Multidisciplinary Science Journal with copies of the consent or evidence that such consent has been obtained if requested.

Conflict of interest

The authors declare that they have no conflicts of interest.

Funding

Thank you to Universitas Muhammadiyah Prof.DR.HAMKA for program Funded in 2024.

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