

Evaluating Learning Management System Usability for In-Service STEM Teacher Training

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ABSTRACT

This study aims to evaluate teachers' perceived usability of a Learning Management System (LMS) implemented in a national STEM pedagogy pilot and to identify priority areas for refinement before large-scale implementation. A quantitative survey was conducted involving 152 senior high school (*Sekolah Menengah Atas/SMA*) and vocational high school (*Sekolah Menengah Kejuruan/SMK*) teachers from 38 Indonesian provinces. Data were collected using a 35-item questionnaire measuring seven dimensions of LMS usability. The findings indicate a high level of perceived usability ($M = 3.814$ out of 4), with the highest ratings observed for compatibility and application performance. Nevertheless, item-level analysis identified several areas requiring improvement, particularly navigation, notification clarity, and helpdesk functionality. This study contributes to the literature by evaluating LMS usability within a government-led, nationwide teacher professional development program involving both STEM and non-STEM teachers, thereby extending previous research that has predominantly focused on institution-based or student-centered settings. The study concludes that the LMS is suitable for broader implementation, provided that identified usability issues are addressed. It recommends that the Ministry of Primary and Secondary Education prioritize improvements to navigation design, notification systems, and user support services to enhance platform usability and sustain teacher engagement in STEM professional development.

KEYWORDS

STEM pedagogy; learning management system; teacher professional development; usability evaluation; educational technology

Introduction

Recent Program for International Student Assessment (PISA) 2022 data indicate that Indonesia continues to perform below the Organisation for Economic Co-operation and Development (OECD) average in Mathematics, reading, and Science. More importantly, Indonesian students continue to experience difficulties applying their reasoning to unfamiliar, real-world problems (OECD, 2023). Developing these competencies requires more coherent learning progressions, for which integrated STEM (Science, Technology, Engineering, Mathematics) education provides a promising approach. When grounded in authentic challenges and structured inquiry, well-designed STEM programs consistently improve conceptual understanding, academic achievement, and higher-

order thinking skills (Cheng & Yeh, 2022; Ting et al., 2023; Wahono et al., 2020; Zhou et al., 2025). However, researchers caution that simply combining disconnected activities is insufficient. The effectiveness of STEM education depends largely on the quality of instructional integration and pedagogical support (Portillo-Blanco et al., 2024).

In response to these challenges, Indonesia has introduced *Pembelajaran Mendalam* (Deep Learning) as a national initiative to improve educational quality and strengthen human capital. The academic paper on *Pembelajaran Mendalam* envisions learning that is mindful, meaningful, and joyful by actively engaging students and connecting learning experiences with their everyday lives (Pusat Kurikulum dan Pembelajaran, 2025). Translating these broad policy aspirations into classroom practice, however, requires strong pedagogical support. Although national policy allows schools flexibility in selecting instructional approaches, STEM education offers a particularly suitable vehicle for realizing the objectives of *Pembelajaran Mendalam*. By engaging students in collaboration, problem-solving, and engineering design, STEM encourages learners to connect concepts across disciplines rather than studying them in isolation (Kelley & Knowles, 2016; Portillo-Blanco et al., 2024).

This policy direction gained further momentum with the publication of the 2025 STEM Learning Guide by the Agency for Standards, Curriculum, and Assessment in Education (BSKAP). The guide repositions STEM from being the exclusive domain of Mathematics and Science teachers to a flexible interdisciplinary framework applicable across learning areas. It promotes integrative learning through intracurricular, cocurricular, and extracurricular activities. Expanding STEM implementation in this way, however, requires substantial enhancement of teachers' professional capacities. If this national strategy is implemented successfully at scale, teachers need more than technical guidance. They require sound pedagogical understanding to design meaningful interdisciplinary learning that aligns with both the national curriculum and local educational contexts.

Making STEM education a widespread instructional practice places teachers at the center of educational transformation because they are responsible for translating curriculum standards into meaningful classroom experiences. Without sufficient confidence and competence to facilitate interdisciplinary inquiry, teachers may struggle to implement STEM effectively, preventing national policy goals from being fully realized. Recognizing this challenge, the Ministry of Primary and Secondary Education launched a national pilot of in-service STEM pedagogy training. Developed under the Directorate General of Teachers and Education Personnel (GTK), the program involved senior and vocational high school teachers from all 38 provinces. Importantly, the pilot intentionally included both MIPA (Mathematics and Natural Sciences) and non-MIPA disciplines teachers. This inclusive approach reflects the view that STEM is a cross-disciplinary pedagogical framework capable of strengthening teaching and learning across subject areas.

To enhance participant engagement, the training adopted a thematic sequence entitled "Seven Formulas for Uncovering the Secrets of the Universe". The learning experience was organized around the narrative character "Garuda Cendekia." The program began with a foundational "STEM Ground Zero" module, followed by seven progressive modules: STEM 5M, Exploration (5E), DNA, Innovation, Creation, Reflection, and Learning Ecosystem. Following experiential learning principles, teachers first participated in learning activities as learners before analyzing the underlying pedagogical concepts and adapting them for their own classrooms. Through this approach, the pilot sought to strengthen teachers' instructional strategies, pedagogical competence, and readiness to implement STEM learning.

The training was delivered through a blended learning model combining face-to-face instruction with structured self-paced learning delivered through a Learning Management System (LMS). Within this professional development model, the LMS functions as more than a repository for learning materials. It shapes teacher's learning experiences by influencing how easily they access learning resources, understand assignment instructions, manage deadlines, and obtain technical support. Consequently, LMS usability plays a critical role in sustaining teacher engagement, particularly when professional development must be balanced with regular teaching responsibilities (Bragg et al., 2021; Philipsen et al., 2019; Sancar et al., 2021). Previous studies have shown that user satisfaction and continued participation depend largely

on system quality, information quality, and service quality (Al-Fraihat et al., 2020). When these dimensions function effectively, teachers are more likely to remain engaged and perceive the LMS as supporting their professional learning objectives (Al-Nuaimi & Al-Emran, 2021; Tulinayo et al., 2018).

Because the pilot was designed to inform future nationwide implementation, empirical evidence regarding the usability of the LMS is essential for determining whether the digital infrastructure can effectively support large-scale, self-directed professional learning. Accordingly, this study evaluates teachers' perceived usability of the LMS during the national STEM pedagogy pilot to identify priorities for improvement before wider implementation. Specifically, the study addresses three research questions: (1) How do teachers evaluate the overall usability of the LMS? (2) How do usability ratings vary across the key dimensions of system use? and (3) Which usability dimensions receive comparatively lower ratings that should be prioritized for improvement before nationwide implementation?

Literature Review

This section reviews the scholarly discourse on Learning Management Systems (LMS) in teacher professional development (PD), identifies gaps in the existing literature, and establishes the novelty of the present study. A theoretical framework is then proposed to guide the analysis of LMS usability data.

Scholarly Discourse: LMS in Teacher Professional Development

The integration of digital technologies into education has transformed teacher professional development from episodic face-to-face workshops to sustained, blended, and self-directed learning models (Philipsen et al., 2019; Sancar et al., 2021). Central to this transformation is the Learning Management System (LMS), which serves as a platform for content delivery, communication, assessment, and learning management. For teachers participating in large-scale national initiatives, the LMS functions not merely as a repository of learning materials but as the primary environment in which professional learning occurs (Bragg et al., 2021). Consequently, its usability directly influences teacher engagement, persistence, and the overall effectiveness of professional development programs.

A substantial body of research demonstrates that the success of e-learning systems depends on three interrelated dimensions: system quality, information quality, and service quality (Al-Fraihat et al., 2020). Within teacher professional development, system quality—including technical stability, accessibility, and application performance—is regarded as a fundamental prerequisite. Reliable operation across devices and browsers encourages teachers to invest time and effort in professional learning (Al-Nuaimi & Al-Emran, 2021; Tulinayo et al., 2018). Conversely, unstable systems and technical difficulties may discourage participation among teachers who have limited time for professional development (Bragg et al., 2021).

Recent studies have also emphasized specific LMS characteristics that influence user experience. Estrada-Molina et al. (2022) and Camilleri and Camilleri (2017) identify usability—defined by the International Organization for Standardization (ISO) as effectiveness, efficiency, and satisfaction in achieving specified goals—as a key determinant of successful LMS adoption. Among the various usability components, navigation and learnability are consistently identified as critical factors. Tulinayo et al. (2018) found that even high quality learning content cannot compete for poor navigation structures, which increase task completion times and user frustration. Likewise, clear notifications and instructional guidance support learner self-regulation by helping users organize tasks and manage learning in self-paced environments (Biswas & Bhattacharya, 2024; Wu, 2022). Without clear instructional cues, the cognitive burden of simply managing the platform can overshadow the learning objectives.

Research Gaps and Novelty

Despite extensive research on LMS usability, an important gap remains regarding its application within large-scale, government-led teacher professional development. Most previous studies have examined institution-based e-learning (Al-Fraihat et al., 2020), higher education students (Al-

Nuaimi & Al-Emran, 2021), or discipline-specific learning contexts. Empirical evidence regarding LMS usability within nationwide teacher professional development programs involving both STEM and non-STEM teachers remains limited.

Furthermore, while STEM education research consistently emphasizes the importance of pedagogical support (Kelley & Knowles, 2016; Portillo-Blanco et al., 2024), relatively little attention has been given to the digital infrastructure required to deliver such support at scale. This study addresses that gap by examining the usability of an LMS implemented within a government-led national STEM pedagogy pilot. By evaluating teachers' perception across a nationally representative sample, this study contributes evidence regarding the readiness of Indonesia's digital professional development infrastructure to support the large-scale implementation of STEM pedagogy.

Theoretical Framework

To examine teachers' perceived usability of the LMS, this study draws upon two complementary theoretical perspectives: the Information Systems (IS) Success Model (DeLone & McLean, 2003) and Cognitive Load Theory (CLT) (Sweller, 1988). The IS Success Model proposes that system quality, information quality, and service quality are primary determinants of user satisfaction and continued system use. These dimensions correspond with the seven usability dimensions examined in this study. For example, system quality is reflected in application performance and loading time, while service quality is represented by helpdesk functionality. Accordingly, the model provides the primary for interpreting the high overall usability scores ($M = 3.814$), indicating that positive perceptions across these quality dimensions contribute to overall user satisfaction.

The IS Success Model, however, does not fully explain the specific cognitive challenges identified by respondents, particularly those associated with navigation and notification systems. To address this limitation, the study also applies Cognitive Load Theory (CLT), which distinguishes between intrinsic cognitive load, arising from the complexity of the learning content itself, and extraneous cognitive load, generated by the manner in which information is presented (Sweller, 1988). Within the present study, the LMS is intended to facilitate teachers' learning. However, when navigation is unclear or instructional guidance is ambiguous, the system imposes unnecessary extraneous cognitive load that diverts teachers' cognitive resources away from learning STEM pedagogy toward managing the interface itself. Viewed together, these theoretical perspectives provide complementary explanatory power. The IS Success Model explains the platform's overall strengths, whereas Cognitive Load Theory helps interpret lower ratings for navigation and notification as sources of avoidable cognitive burden that should be addressed before nationwide implementation.

Research Methods

Study Design and Context

To examine teachers' perceptions of the Learning Management System (LMS) during the national STEM pedagogy pilot, this study employed a cross-sectional survey design. The training adopted a blended learning approach that combined facilitated face-to-face sessions with self-paced digital modules. For participants, the LMS served as the central learning platform, enabling them to access instructional materials, complete worksheets, and undertake pretest and posttests. The platform also supported administrative functions, including attendance recording, progress monitoring, notifications, and helpdesk services. This study specifically evaluated teachers' perceived usability of the LMS as the digital support system underpinning nationwide teacher professional development.

Participants and Sampling

The pilot involved 152 teachers representing all 38 provinces of Indonesia. Each province nominated one school, and each participating school delegated four teachers. Participants represented both Science and Mathematics (*MIPA*) disciplines (Mathematics, Chemistry, Physics, and Biology) and non-*MIPA* subjects, including English and Religious Education. They were

drawn from Senior High Schools (*Sekolah Menengah Atas/SMA*) and Vocational High Schools (*Sekolah Menengah Kejuruan/SMK*).

A total sampling (census) approach was employed by inviting all pilot participants to complete the survey. Of the 152 participants, 140 submitted complete questionnaires, resulting in a response rate of 92.1%. Twelve participants were excluded because of incomplete responses ($n = 8$) or nonresponse ($n = 4$). This relatively low attrition is unlikely to affect the integrity of the findings.

Because the study was designed to evaluate LMS usability within a specific government-led pilot program, the sample ($n = 140$) was not intended to support statistical generalization to the broader population of Indonesian teachers. Rather, the study aimed to generate rich contextual insights and identify usability issues across 38 geographically diverse provinces, thereby providing evidence to support system refinement before large-scale implementation. Despite the modest sample size, representation from all provinces provides broad coverage of diverse educational contexts. Demographic information, including sex and educational attainment, was also collected and is presented in the Results section (Figures 1 and 2).

Measures and Instrument

Teachers' perceptions of LMS usability were measured using a 35-item questionnaire. Responses were recorded on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The questionnaire comprised seven dimensions representing key aspects of LMS usability: Compatibility, Navigation, Application Performance, Features, Usability, Aesthetics, and Loading Time. Table 3 presents the mapping of questionnaire items to each usability dimension.

Ethical Considerations and Data Management

Participants were informed that their responses would be used to improve future professional development programs and subsequent LMS enhancements. Participation was voluntary, and completion of the questionnaire constituted informed consent. To protect participants' privacy, all personal identifiers were removed before analysis, and only aggregated findings are reported. The usability survey was intentionally separated from formal training assessments. Survey participation had no effect on certification or performance evaluation, thereby minimizing potential conflicts of interest and response bias. All de-identified datasets were securely stored and were accessible only to the research team.

Data Collection Procedure and Data Analysis

Data were collected after participants has used the LMS to complete independent learning activities during the STEM pedagogy pilot. The questionnaire was administered online and completed individually. Descriptive statistical analyses were conducted for all questionnaire items and usability dimensions. Means, standard deviations, and 95% confidence intervals were calculated for each item and dimension. Top-two-box percentages—that is, the proportion of respondents selecting agree or strongly agree—were also calculated. To facilitate interpretation, mean scores were converted to a 0–100 index using the following formula: $\text{Index} = (\text{Mean} - 1) \div 3 \times 100$. Cronbach's alpha was calculated to assess the internal consistency reliability of the instrument. Only complete questionnaires were included in the final analysis.

Research Findings

Respondent Distribution

A total of 152 teachers participated in the STEM pedagogy pilot, of whom 140 completed the LMS usability questionnaire, resulting in a response rate of 92.1%. The respondents represented all 38 provinces and intentionally included teachers from both Mathematics and natural Sciences (*MIPA*) and non-*MIPA* subject areas. Female teachers constituted the majority of respondents ($n = 93$; 66.4%), while male teachers accounted for 33.6% ($n = 47$) (Figure 1). In terms of educational attainment, most respondents held a bachelor's degree ($n = 96$; 68.6%) followed by a master's degree ($n = 42$; 30.0%) and a doctoral degree ($n = 2$; 1.4%) (Figure 2). Participants were distributed

relatively evenly across the four STEM pilot classes, providing balanced representation for subsequent analyses (Table 1).

Table 1

Respondent Distribution by Class

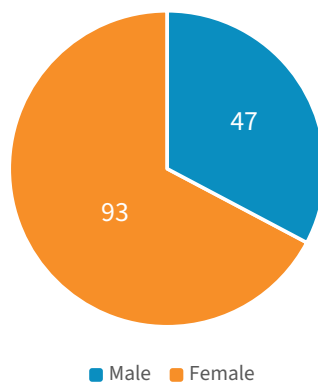
Class (STEM Pilot Group)	n	%
Class B	36	25.7
Class A	35	25.0
Class C	35	25.0
Class D	34	24.3

*N = 140

Source: Authors' Data Analysis

Figure 1

Distribution of Respondents by Sex

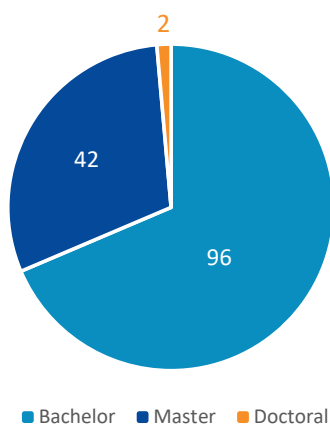


*N = 140, Female = 93 (66.4%), Male = 47 (33.6%)

Source: Authors' Data Analysis

Figure 2

Highest Educational Attainment of Respondents



*N = 140, Bachelor's degree = 96 (68.6%), Master's degree = 42 (30.0%), Doctoral degree = 2 (1.4%)

Source: Authors' Data Analysis

Overall Evaluation

Overall, teachers reported highly positive perceptions of the Learning Management System (LMS). The overall usability score was high ($M = 3.814$, $SD = 0.361$, 95% CI [3.754, 3.874]), indicating strong agreement regarding the LMS's effectiveness in supporting participation in the STEM pedagogy pilot. The usability instrument also demonstrated excellent internal consistency reliability (Cronbach's $\alpha = 0.983$), indicating a high degree of consistency among the questionnaire items.

Dimension-Level Results

Mean scores across the seven usability dimensions ranged from 3.770 to 3.861 (Table 2; Figure 3), indicating consistently positive evaluations of the LMS. Compatibility received the highest mean score ($M = 3.861$), followed by Aesthetics ($M = 3.838$) and Application Performance ($M = 3.831$). Navigation received the lowest mean score ($M = 3.770$), although it remained within the high-agreement category. Features and Loading Time received slightly lower ratings than the highest-scoring dimensions; however, these differences were relatively small, indicating consistently favorable perceptions across all aspects of system usability.

Table 2

Dimension-Level Descriptive Statistics and Reliability

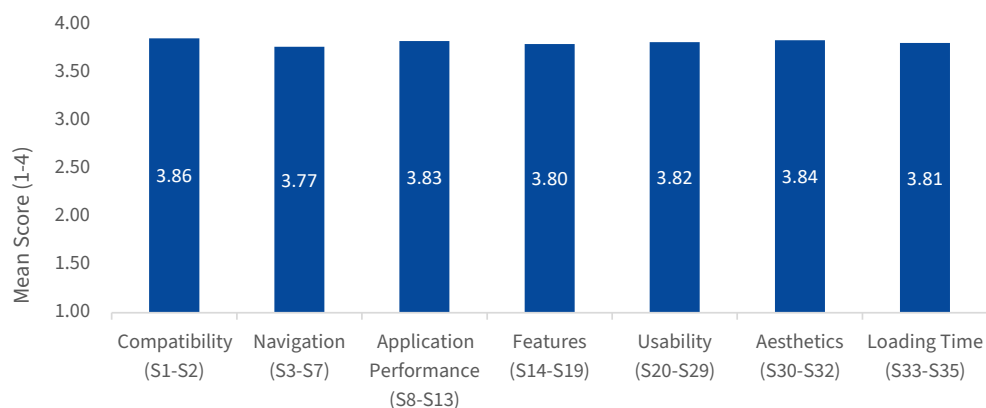
Dimension	Items	Mean	SD	Top-Two-Box (%)	Cronbach's	Index (0–100)
Compatibility (Q1–Q2)	2	3.861	0.384	98.571	0.842	95.357
Navigation (Q3–Q7)	5	3.770	0.424	97.857	0.902	92.333
Application Performance (Q8–Q13)	6	3.831	0.370	99.286	0.927	94.365
Features (Q14–Q19)	6	3.800	0.388	98.571	0.928	93.333
Usability (Q20–Q29)	10	3.819	0.380	99.286	0.960	93.952
Aesthetics (Q30–Q32)	3	3.838	0.397	98.571	0.853	94.603
Loading Time (Q33–Q35)	3	3.814	0.431	97.857	0.923	93.810

*Top-two-box = Agree + Strongly Agree, Index (0–100) = $(\text{Mean} - 1) \div 3 \times 100$

Source: Authors' Data Analysis

Figure 3

Mean LMS Evaluation Scores by Dimension with 95% Confidence Intervals



*N = 140, Scale: 1 = Strongly Disagree, 4 = Strongly Agree

Source: Authors' Data Analysis

Comparing demographic characteristics across the usability dimensions provides important insights into the user experience. Overall, a high degree of consistency was observed across demographic groups, suggesting that the system provided a comparable user experience for all participants. The comparison of male and female respondents indicated a high level of consistency across all seven dimensions (Table 3; Figure 4). Mean scores were highly comparable, ranging from core functionality, such as Navigation, to more subjective dimensions, such as Aesthetics. Only minimal differences were observed between the two groups, suggesting that the LMS interface did not systematically favor or disadvantage users based on sex.

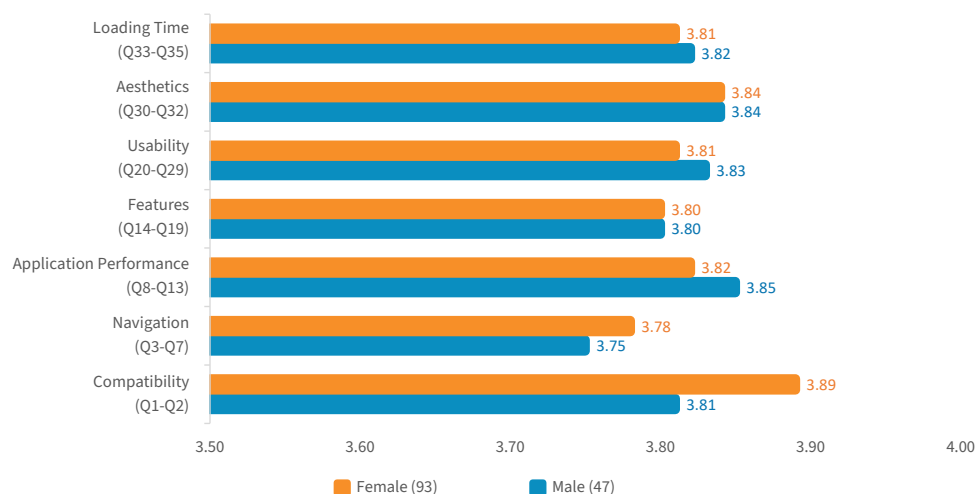
A slight difference was observed in the variability of responses. Standard deviations were generally higher among male respondents, indicating greater variation in their perceptions, whereas female respondents reported more homogeneous evaluations. Nevertheless, the overall pattern of responses was highly consistent across both groups, suggesting that sex was not a meaningful differentiating factor in teachers's perception of LMS usability. These findings support the conclusion that the LMS provided a consistent and inclusive user experience for both male and female teachers.

Table 3
Comparative Analysis of LMS Usability Scores by Sex

Dimension	Items	Male (47)		Female (93)	
		Mean	SD	Mean	SD
Compatibility (Q1–Q2)	2	3.81	0.55	3.89	0.32
Navigation (Q3–Q7)	5	3.75	0.61	3.78	0.44
Application Performance (Q8–Q13)	6	3.85	0.51	3.82	0.39
Features (Q14–Q19)	6	3.80	0.54	3.80	0.40
Usability (Q20–Q29)	10	3.83	0.53	3.81	0.39
Aesthetics (Q30–Q32)	3	3.84	0.56	3.84	0.39
Loading Time (Q33–Q35)	3	3.82	0.57	3.81	0.40

Source: Authors' Data Analysis

Figure 4
Comparative Analysis of LMS Usability Scores by Sex



Source: Authors' Data Analysis

Analysis by educational attainment revealed a similar pattern of consistency (Table 4, Figure 5). LMS usability scores were compared between respondents holding undergraduate and graduate degrees. The largest observed difference between the two groups was only 0.04. On a four-point Likert scale, this difference is not practically meaningful and suggests a high degree of consistency in perceived usability across educational levels.

These findings indicate that the LMS effectively accommodated teachers with different educational backgrounds. The consistently high ratings suggest that the system's information architecture was appropriately designed to support users with varying levels of academic preparation. The LMS appeared to be equally accessible to teachers holding undergraduate and graduate degrees, with no evidence that the system disproportionately favored or disadvantaged either group.

Table 4

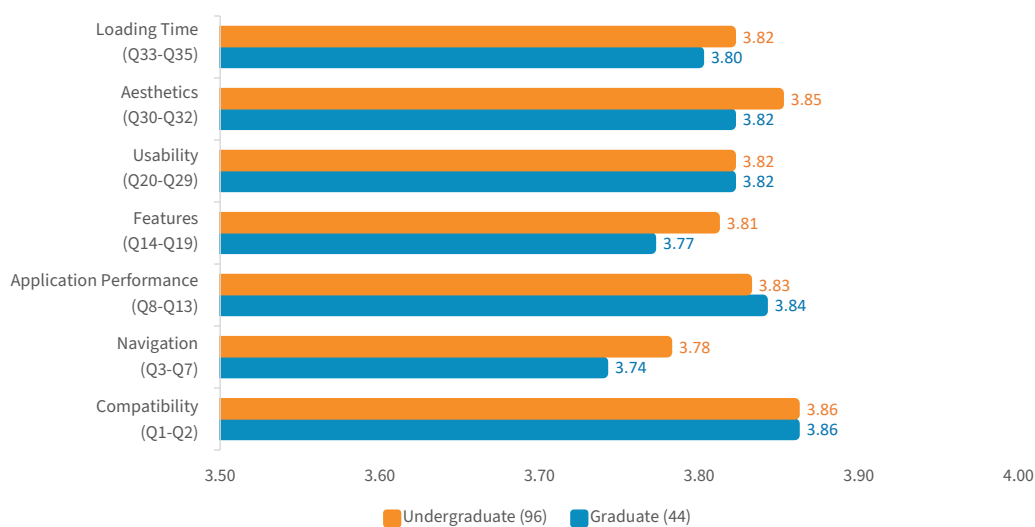
Mean and Standard Deviation of LMS Usability Dimensions by Participants' Education Level

Dimension	Items	Undergraduate (96)		Graduate (44)	
		Mean	SD	Mean	SD
Compatibility (Q1-Q2)	2	3.86	0.43	3.86	0.38
Navigation (Q3-Q7)	5	3.78	0.49	3.74	0.52
Application Performance (Q8-Q13)	6	3.83	0.46	3.84	0.37
Features (Q14-Q19)	6	3.81	0.46	3.77	0.43
Usability (Q20-Q29)	10	3.82	0.46	3.82	0.39
Aesthetics (Q30-Q32)	3	3.85	0.45	3.82	0.44
Loading Time (Q33-Q35)	3	3.82	0.48	3.80	0.42

Source: Authors' Data Analysis

Figure 5

Mean LMS Usability Scores by Participants' Educational Attainment



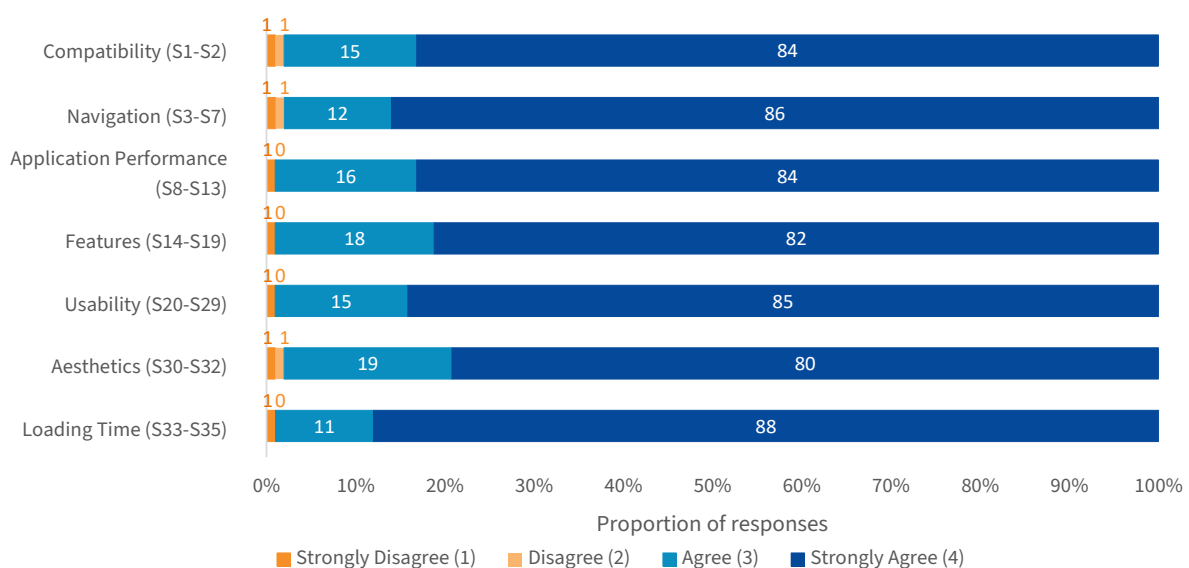
Source: Authors' Data Analysis

Response Distribution (Evidence of High Agreement)

Figure 6 illustrates the distribution of responses across the four-point Likert scale. Responses were concentrated predominantly in the “agree” and “strongly agree” categories across all usability dimensions, indicating consistently positive perceptions of the LMS. Although this distribution is consistent with the high mean scores reported in the preceding analyses, it also suggests the presence of a modest ceiling effect, which is commonly observed in user satisfaction surveys. Consequently, mean scores alone provide only a partial understanding of respondents’ perceptions. A more detailed examination of individual questionnaire items is therefore warranted to identify specific aspects of the LMS that may benefit from further improvement. The item-level analysis presented in the following section provides this additional diagnostic information.

Figure 6

Response Distribution by LMS Usability Dimension (Four-Point Likert Scale)



*Responses are aggregated across all items within each usability dimension.

Source: Authors' Data Analysis

Item-Level Results

Item-level analysis identified specific aspects of the Learning Management System (LMS) with comparatively lower ratings (Table 5 and Figure 7). The lowest mean scores were associated with navigation between menus (Q4, $M = 3.714$), returning to previous screens (Q5, $M = 3.714$), and the clarity of assignment instructions (Q7, $M = 3.736$). Relatively lower ratings were also observed for system learnability (Q20, $M = 3.757$), response storage speed (Q10, $M = 3.764$), and the reliability of assignment uploads (Q13, $M = 3.771$). In addition, notification clarity (Q6, $M = 3.786$), screen transitions (Q34, $M = 3.807$), and Helpdesk menu functionality (Q27, $M = 3.821$) received comparatively lower evaluations. Although all items remained within the high-agreement category, these findings highlight priority areas for future LMS refinement.

Table 5

Item-Level Descriptive Statistics (Q1–Q35)

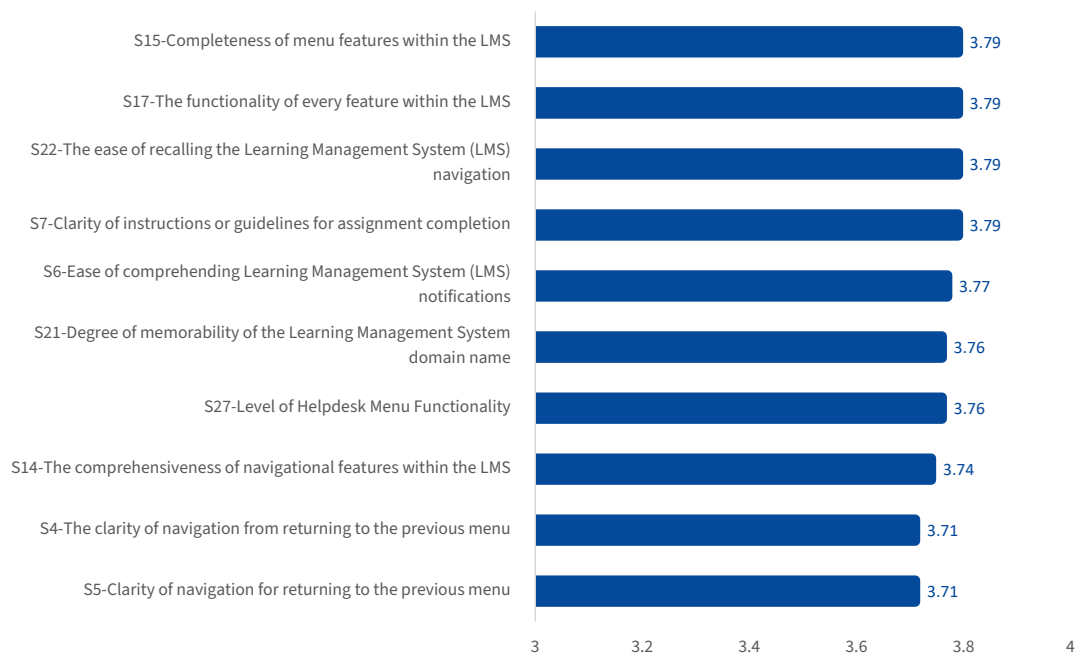
Q	Dimension	Item	Mean	SD	Top-Two-Box (%)	Strongly agree (%)
Q1	Compatibility (Q1–Q2)	Readability and visual compatibility of the LMS across desktop computers, laptops, tablets, and mobile devices	3.857	0.425	98.571	87.857

Q	Dimension	Item	Mean	SD	Top-Two-Box (%)	Strongly agree (%)
Q2	Compatibility (Q1–Q2)	Compatibility of the LMS across web browsers (e.g., Google Chrome, Mozilla Firefox, Microsoft Edge, and Opera)	3.864	0.402	99.286	87.857
Q3	Navigation (Q3–Q7)	Ease of the login process	3.864	0.402	99.286	87.857
Q4	Navigation (Q3–Q7)	Clarity of navigation between menus	3.714	0.553	97.857	75.000
Q5	Navigation (Q3–Q7)	Ease of returning to the previous menu	3.714	0.566	97.143	75.714
Q6	Navigation (Q3–Q7)	Clarity of LMS notifications	3.786	0.461	99.286	80.000
Q7	Navigation (Q3–Q7)	Clarity of instructions for completing assignments	3.736	0.503	98.571	75.714
Q8	Application Performance (Q8–Q13)	System responsiveness when saving user input during learning activities	3.793	0.457	99.286	80.714
Q9	Application Performance (Q8–Q13)	Reliability of preserving submitted user data during learning activities	3.857	0.408	99.286	87.143
Q10	Application Performance (Q8–Q13)	Speed of saving user responses	3.764	0.474	99.286	77.857
Q11	Application Performance (Q8–Q13)	Reliability of saving responses to assessment questions	3.821	0.413	99.286	84.286
Q12	Application Performance (Q8–Q13)	Timeliness of assignment submission	3.821	0.445	98.571	85.000
Q13	Application Performance (Q8–Q13)	Reliability of assignment upload functionality	3.771	0.500	97.857	80.000
Q14	Features (Q14–Q19)	Completeness of LMS navigation features	3.793	0.457	99.286	80.714
Q15	Features (Q14–Q19)	Completeness of LMS menu features	3.800	0.436	98.571	82.143
Q16	Features (Q14–Q19)	Clarity of LMS features	3.871	0.395	99.286	88.571
Q17	Features (Q14–Q19)	Functionality of LMS features	3.850	0.414	99.286	86.429
Q18	Features (Q14–Q19)	Ease of using LMS features	3.843	0.437	98.571	86.429

Q	Dimension	Item	Mean	SD	Top-Two-Box (%)	Strongly agree (%)
Q19	Features (Q14–Q19)	Visual attractiveness of LMS features	3.843	0.420	99.286	85.714
Q20	Usability (Q20–Q29)	Operational simplicity and learnability of the LMS	3.757	0.493	98.571	77.857
Q21	Usability (Q20–Q29)	Ease of remembering the LMS domain name	3.786	0.461	99.286	80.000
Q22	Usability (Q20–Q29)	Ease of recalling LMS navigation	3.829	0.403	99.286	84.286
Q23	Usability (Q20–Q29)	Readability of instructional materials in the LMS content preview	3.829	0.403	99.286	84.286
Q24	Usability (Q20–Q29)	Ease of downloading instructional materials	3.836	0.394	99.286	84.286
Q25	Usability (Q20–Q29)	Functionality of the attendance feature	3.850	0.414	99.286	86.429
Q26	Usability (Q20–Q29)	Functionality of the assessment feature (pretest/posttest)	3.829	0.403	99.286	84.286
Q27	Usability (Q20–Q29)	Functionality of the Helpdesk menu	3.821	0.413	99.286	84.286
Q28	Usability (Q20–Q29)	Functionality of the instructional materials menu	3.836	0.394	99.286	84.286
Q29	Usability (Q20–Q29)	Functionality of the instructional materials menu	3.821	0.413	99.286	84.286
Q30	Aesthetics (Q30–Q32)	Visual appearance and layout of the LMS interface	3.857	0.425	98.571	87.857
Q31	Aesthetics (Q30–Q32)	Visual appeal of the LMS color scheme	3.800	0.447	97.857	82.857
Q32	Aesthetics (Q30–Q32)	Readability and comfort of the default font size (100% display)	3.857	0.408	99.286	87.143
Q33	Loading Time (Q33–Q35)	Time required for the LMS home page to load	3.821	0.474	97.857	85.714
Q34	Loading Time (Q33–Q35)	Time required to move between menus or sections	3.807	0.475	98.571	83.571
Q35	Loading Time (Q33–Q35)	Duration before re-authentication is required during LMS use	3.814	0.506	97.143	85.714

Figure 7

Top 10 Lowest-Rated LMS Items (Mean Scores with 95% Confidence Intervals): Priority Areas for LMS Usability Improvement



Source: Authors' Data Analysis

Discussion

This discussion interprets the principal findings by relating them to the quantitative results and relevant literature. Overall, teachers perceived the LMS as an effective platform for supporting professional development. The high overall usability score ($M = 3.814$, $SD = 0.361$, 95% CI [3.754, 3.874]) and consistently positive ratings across all usability dimensions indicate that participants were generally able to access learning materials and complete learning activities without substantial difficulty. As shown in Table 2, the Top-two-box percentage exceeded 97.8% across all dimensions indicating broad acceptance of the platform's core functionality. When converted to a 0–100 usability index, all dimensions exceeded 92 points, further indicating a high level of overall usability. These findings are particularly important because teachers participating in professional development must balance training activities with demanding instructional responsibilities, sustained participation therefore depends on an LMS that is efficient, reliable, and easy to use (Bragg et al., 2021; Philipsen et al., 2019).

These findings are consistent with established models of e-learning success, which emphasize that system quality, information quality, and service quality are key determinants of continued system use (Al-Fraihat et al., 2020). In practical terms, teachers are more likely to remain engaged when the platform functions reliably, provides clear instructional guidance, and offers timely technical support. The high ratings for compatibility and system performance are also consistent with previous studies linking perceived ease of use with sustained engagement in online learning (Al-Nuaimi & Al-Emran, 2021; Tulinayo et al., 2018). Within teacher professional development, this reliability is particularly important because limited time and competing professional responsibilities can amplify the effects of even minor technological barriers (Bragg et al., 2021).

Despite these positive overall findings, the item-level analysis reveals several recurring usability challenges. Lower ratings consistently clustered around navigation, system communication, helpdesk accessibility, and system responsiveness. Although these dimensions remained within the high usability category, their comparatively lower scores suggest opportunities for improvement. However, we cannot ignore these relative dips. In massive training programs featuring endless deadlines and repeated logins, minor confusions quickly

compound into major frustrations. Consequently, future platform development should focus on targeted refinements that reduce unnecessary user effort during routine tasks.

Navigation emerged as the area requiring the greatest attention. It received the lowest mean score among the seven usability dimensions ($M = 3.770$) (Table 2; Figure 3). It serves as the primary foundation of self-directed learning. If menu labels and digital pathways feel ambiguous, teachers end up wasting cognitive energy deciphering the interface rather than learning. Our item-level diagnostics back this up empirically. The two lowest-scoring questionnaire items related to navigating between menus (Q4, $M = 3.714$) and returning to previous pages (Q5, $M = 3.714$). Only 75% of respondents selected "strongly agree" for these items (Table 5).

Previous studies consistently identify navigation and learnability as fundamental determinants of LMS usability. Researchers recommend combining perception-based measures with task-based usability indicators, such as task completion time and navigation efficiency, to identify specific usability barriers (Camilleri & Camilleri, 2017; Estrada-Molina et al., 2022; Tulinayo et al., 2018). Viewed from this perspective, the present findings suggest that improvements to the platform's information architecture could facilitate routine activities such as locating assignments, monitoring progress, and confirming successful submissions.

System communication represents the second area requiring improvement, particularly regarding notifications and instructional clarity. In blended learning environments, effective notification systems support learner self-regulation by providing timely reminders and clear instructional guidance. However, this benefit depends on notifications being understandable, timely, and actionable. The present findings indicate that this remains an area for refinement. Item Q7, measuring the clarity of assignment instructions, received one of the lowest mean scores ($M = 3.736$), with only 75.7% of respondents selecting "strongly agree" (Table 5). Similarly, Item Q6, which assessed the clarity of LMS notifications, also received comparatively lower ratings ($M = 3.786$).

Previous research suggests that well-designed notification systems enhance learner engagement by providing timely prompts that support sustained participation in online learning (Biswas & Bhattacharya, 2024; Tran et al., 2025; Wu, 2022). For teachers balancing classroom responsibilities with professional development, effective notifications reduce the likelihood of missed deadlines and improve learning management. Conversely, unclear or poorly timed notifications may increase unnecessary cognitive load and reduce user engagement. Accordingly, simplifying notification language, establishing clear priority levels, and synchronizing reminders with assignment deadlines represent practical opportunities for improving system usability.

Helpdesk functionality and system responsiveness constitute a third area for improvement. Within blended professional development, accessible technical support is essential for sustaining teacher participation (Bragg et al., 2021; Philipsen et al., 2019). Although helpdesk functionality received generally positive ratings, Item Q27 ranked among the lower-scoring usability items (Table 5), suggesting that support services could be strengthened.

Similarly, respondents identified concerns regarding technical responsiveness. Items assessing response processing speed (Q10, $M = 3.764$) and assignment upload reliability (Q13, $M = 3.771$) also received comparatively lower ratings (Figure 7). Previous studies indicate that rapid and transparent technical support is particularly important during online professional development, where unresolved technical issues may reduce user confidence and participation (Heap et al., 2021; Xie et al., 2017). Practical improvements such as visible support links, transparent ticket-tracking systems, and faster response mechanisms, could substantially improve users' perceptions of system reliability.

The measurement instrument itself also warrants consideration. As reported earlier, the questionnaire demonstrated excellent internal consistency ($\alpha = 0.983$). Although this indicates high reliability, such a coefficient may also suggest redundancy among questionnaire items, with multiple items measuring highly similar aspects of perceived usability rather than distinct constructs (Taber, 2018; Zakariya, 2022). Accordingly, future studies should report McDonald's omega alongside Cronbach's alpha and consider refining the instrument by removing redundant items while maintaining adequate construct coverage (Hayes & Coutts, 2020). In addition, because responses were concentrated within the upper response categories, future evaluations

would benefit from incorporating complementary evidence, including system log data, usability testing, and qualitative user feedback, to improve diagnostic precision.

The demographic analyses presented in Tables 3 and 4 and Figures 4 and 5 further strengthen the interpretation of the findings. Mean usability scores were highly consistent across gender and educational attainment. Differences between male and female teachers, as well as between teachers holding undergraduate and graduate degrees, were minimal, with the largest observed difference being only 0.04 points. These findings suggest that positive usability perceptions were largely attributable to the LMS itself rather than to demographic characteristics of the respondents. Such consistency is particularly important for a government-supported digital platform intended for nationwide implementation because it indicates that teachers from different demographic groups experienced similar strengths and limitations.

Several limitations should be acknowledged. *First*, the study relied on self-reported perceptions collected at a single point in time, which may reflect participants' overall satisfaction with the STEM professional development program in addition to their perceptions of the LMS. *Second*, although participants represented 38 provinces, the sample was drawn from an initial pilot cohort, and future large-scale implementation may reveal additional usability challenges associated with broader participation and regional variation in digital infrastructure. *Third*, the analysis was descriptive and did not examine relationships between usability perceptions and learning outcomes, course completion, or actual system use. Future research should integrate user perceptions with system log data, usability testing, and learning analytics to determine whether improvements in lower-rated usability dimensions contribute to increased participation, engagement, and professional learning outcomes (Estrada-Molina et al., 2022).

Conclusion and Policy Recommendations

The findings indicate that the Learning Management System (LMS) used in the national STEM pedagogy pilot is technically viable and pedagogically appropriate for broader implementation, provided that several usability issues are addressed. Overall, the platform demonstrated high perceived usability ($M = 3.814$), with particularly strong performance in Compatibility and Application Performance. These findings directly the study's first research question by indicating that the digital infrastructure is capable of supporting the Ministry of Primary and Secondary Education's blended teacher professional development strategy across Indonesia's geographically diverse regions. The high compatibility score suggests that the LMS performs consistently across a wide range of devices and technological environments, an essential prerequisite for equitable access to professional development.

However, technical robustness alone does not guarantee an optimal user experience. The findings identified specific usability challenges related to the "Navigation" and "Notification" dimensions that may increase users' extraneous cognitive load during independent learning. Although teachers were generally able to access learning materials successfully, limitations in navigation and system feedback reduced the efficiency of the learning process. Because STEM pedagogy and the Deep Learning approach already require substantial cognitive engagement, the LMS should minimize unnecessary cognitive demands rather than add to them. Consequently, although the platform is suitable for broader implementation, improvements to the user interface and navigation structure remain essential. These refinements would enable teachers to focus on developing STEM pedagogical competencies rather than managing interface-related difficulties.

Based on these findings, three policy recommendations are proposed. *First*, the Directorate General of Teachers and Education Personnel (GTK), particularly the Learning Technology Development Team, should prioritize improving the LMS navigation structure before nationwide implementation. Because navigation received comparatively lower usability ratings, the menu hierarchy should be redesigned to support more intuitive user interaction. Practical improvements include implementing a standardized breadcrumb navigation system and providing a persistent "Help/Guide" button on every page. These enhancements are expected to reduce user disorientation, particularly among teachers with lower levels of digital proficiency, and enable the LMS to function as an effective facilitator of STEM professional development.

Second, the committee responsible for national in-service teacher training should strengthen technical support by establishing a tiered rapid response helpdesk system. The findings identified helpdesk responsiveness as one of the weaker aspects of the LMS. Rather than relying solely on conventional ticket-based support, a two-tier support model is recommended. An AI-assisted chatbot could provide immediate responses to common technical questions (Tier 1), while dedicated personnel address more complex technical and pedagogical issues (Tier 2). More responsive support services are expected to enhance teacher engagement and reduce interruptions during self-paced learning.

Finally, the Ministry of Primary and Secondary Education should adopt the LMS as the standard platform for future STEM teacher professional development after the recommended usability improvements have been implemented. Instead of developing multiple training platforms, future investment should focus on optimizing existing platform features, strengthening system stability, and expanding server capacity. Consolidating professional development within a single, continuously improved LMS would reduce teachers' learning burden, improve system consistency, and facilitate longitudinal monitoring of teacher participation and professional learning outcomes.

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