

Designing and validating a gender-responsive learning management system to support equitable digital interaction

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Abstract

This study aimed to design and validate a gender-responsive Learning Management System that promotes equitable digital interaction in upper secondary education. Although gender disparities in access and participation have narrowed, conventional LMS discussions may maintain unequal participation patterns at a structural level. Using a Research and Development approach based on the ADDIE model, this study involved 500 Grade XI students and 8 sociology teachers from four public schools. The system was designed by incorporating structured discussion sequencing, role rotation, guided response prompts, participation visibility dashboards, and learning analytics monitoring. Content validity was evaluated using the Content Validity Index, while system effectiveness was measured through pre-post analysis of digital interaction indicators, including degree centrality, response reciprocity, contribution concentration among the top 25% of students, and the Digital Participation Equity Index. The results showed high validity across all components (CVI = 0.90–0.95). Following eight weeks of implementation, participation distribution and interaction balance increased significantly ($p < .001$), with degree centrality improving from 0.032 to 0.046 and the equity index increasing from 0.71 to 0.89. User perceptions indicated strong acceptance of the system’s fairness and usability. These results show that gender-responsive LMS design can support more equitable and balanced digital participation in practice.

Keywords: Equitable digital interaction, Gender-responsive LMS, Instructional design, Learning analytics, Participation equity, Upper secondary education.

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Contribution of this paper to the literature

This study contributes an empirically validated gender-responsive LMS design model that integrates structured discussion sequencing, role rotation, guided prompts, participation dashboards, and learning analytics to promote equitable digital interaction in upper secondary education.

1. Introduction

The use of Learning Management Systems (LMS) in secondary education has gradually changed learning from one-way content delivery into a more interactive digital space for discussion, collaboration, and knowledge construction (Ingkavara, Panjaburee, Srisawasdi, & Sajjanaroj, 2022). In practice, an LMS is not only a place to upload materials but also a learning environment where students present ideas, respond to their peers, and build understanding through online dialogue (Alkhawaja, Abd Halim, Abumandil, & Al-Adwan, 2022; Sáiz-Manzanares et al., 2021). Previous studies also show that the way a digital platform is designed can affect participation, the quality of interaction, and student engagement in online discussions. For this reason, LMS design should not be viewed as neutral, because it can shape communication patterns and influence how participation is distributed in digital learning activities (Goh, 2026).

Within this digital learning context, gender is an important aspect to consider because it may influence how students communicate and participate in online discussions. Even when the participation gap between male and female students is not clearly visible, differences may still appear in communication styles, argumentation patterns, and the distribution of responses, which are often shaped by wider social and cultural norms (Dobrokhotoev et al., 2025; Herut, 2026; Salam et al., 2026). Therefore, LMS design needs to adopt a preventive and gender-responsive approach so that online learning spaces can encourage fair and inclusive participation. However, many previous studies still focus mainly on LMS use or general learning outcomes, while research that directly integrates gender sensitivity into LMS design principles remains limited (Muharni, Mahanal, Zubaidah, & Susanto, 2025; Utami, Fakhruzzaman, Fahmiyah, Masduki, & Kamil, 2021).

Despite the growing use of LMS platforms in secondary education, many systems are still designed mainly to support content delivery, course management, and technical administration rather than equitable interaction. From a gender perspective, this limitation is important because discussion tools, response systems, and interaction structures can influence who becomes more visible, who responds more actively, and whose ideas receive more attention in online learning spaces (Al-Fraihat et al., 2025; Komariah, Amanah, & Mujayapura, 2025; Suryani et al., 2024). If these spaces are not intentionally structured, LMS-based discussions may unintentionally reproduce unequal patterns of participation, even when male and female students have the same access to the platform. Therefore, this study addresses the need for an LMS design model that systematically integrates gender-responsive principles to support fair, active, and pedagogically meaningful digital interaction (Maryati, Fisher, Mohd Yatim, & Mauladaniyati, 2024; Pacheco, Yupanqui, Mogrovejo, Garay, & Uribe-Hernández, 2025).

Previous literature in educational technology shows that the quality of online interaction is closely connected to the instructional design principles and participation structures embedded in digital learning platforms (Efiloğlu Kurt, 2023; Johnston, Wells, Shanks, Boey, & Parsons, 2024). In this sense, interaction in an LMS is not only determined by students' willingness to participate, but also by how discussion activities are organized, how students are guided to respond, how feedback is provided, and how participation is made visible. Approaches such as culturally responsive pedagogy, inclusive instructional design, and equitable participation frameworks emphasize the need for structured discussion features, balanced content representation, and feedback mechanisms that help distribute students' voices more fairly. Recent studies also highlight the value of learning analytics for monitoring students' interaction patterns, including contribution frequency, peer responses, and discussion network dynamics, as indicators for evaluating participation equity in online environments (Ajani, Govender, & Gamede, 2025; Muhmad Asri, Singh, Mansor, & Norman, 2024). Therefore, improving LMS access alone is not sufficient; the platform also needs to embed pedagogical and analytical features that can support more equitable digital participation.

Based on these considerations, this study aims to design and validate a gender-responsive Learning Management System (LMS) that supports more equitable digital interaction in upper secondary education. The study applies the ADDIE instructional design framework to develop LMS features that integrate structured discussion stages, role rotation, guided prompts, participation dashboards, and learning analytics indicators to encourage balanced student participation. Unlike previous studies that mainly discuss LMS effectiveness in general terms or describe gender differences in online learning, this study focuses on how gender-responsive principles can be operationalized directly into LMS design and evaluated through measurable interaction indicators. The novelty of this research lies in the integration of gender-responsive instructional design with digital participation analytics to produce a validated LMS model that promotes fairer and more inclusive online interaction among students.

2. Literature Review

2.1. Learning Management Systems as Digital Interaction Environments

The development of Learning Management Systems (LMS) during the last decade shows a shift from systems used mainly for learning administration to digital interaction spaces that influence academic communication dynamics (Handayani, Tiara, Mansor, & Zulherman, 2025; Ingkavara et al., 2022). LMS are no longer limited to managing materials and assessments, but also serve as social infrastructures where students take part in discussions, build arguments, and respond to ideas in online settings (Alkhawaja et al., 2022; Sáiz-Manzanares et al., 2021). From the perspective of social and constructivist learning, interaction among learners is an important element in developing conceptual understanding. Therefore, LMS can be viewed as digital mediation spaces that both facilitate and shape participation patterns and the distribution of voice in the learning process (Goh & Yang, 2021; Ibrahim, Ermatita, & Saparudin, 2022).

Recent studies in educational technology highlight that the structural design of LMS, including forum organization, threaded reply systems, notifications, and contribution visibility, influences how students participate in online discussions (Al-Fraihat et al., 2025; Efiloğlu Kurt, 2023). Designs that lack structure may lead to irregular

interaction and dominance by certain participants, while pedagogically structured designs can support more balanced and reflective participation (Muharni et al., 2025; Utami et al., 2021). In digital learning, interaction design views platform features as elements that influence dialogue quality, argumentative depth, and the continuity of discussion. Thus, LMS should not be seen as neutral systems, but as digital architectures that have implications for equity and participation distribution in online learning environments (Al-Fraihat et al., 2025; Komariah et al., 2025; Suryani et al., 2024).

In secondary education, LMS play an increasingly important role as digital interaction environments because students are beginning to develop critical thinking skills and the ability to express arguments (Limonthy & Madyatmadja, 2024; Sorina, 2024). At this level, the interaction structures built into an LMS may affect who participates, how students formulate responses, and how fairly dialogue takes place (Ajani et al., 2025; Goh & Yang, 2021). For this reason, viewing LMS as socio-digital systems creates opportunities to design participation mechanisms that are more structured and inclusive. This perspective provides a conceptual basis for examining how LMS design can be further developed to support equitable and pedagogically structured digital interaction. However, much of the existing literature still views LMS interaction as a broad sign of engagement, rather than analyzing how particular platform features influence the distribution of student participation. This limitation indicates the need for LMS design studies that go beyond counting interaction frequency and instead examine how discussion structures, feedback mechanisms, and monitoring tools can be deliberately designed to support more equitable digital participation.

2.2. Gender and Digital Interaction in Educational Contexts

Studies on gender in digital learning environments have shifted from a primary concern with technology access to closer examinations of participation dynamics and communication patterns (Berhanu, Ayele, & Naidoo, 2026; Chen, Guo, & Liang, 2026). In current educational settings, the gap in access between male and female students appears to be narrowing, especially at the secondary education level (Amoak & Najjar, 2026; Sharma & Goswami, 2025). Even so, several studies show that digital interaction can still be shaped by wider social norms, including the ways individuals express opinions, respond to arguments, and position themselves in online discussions (El Ouahabi et al., 2025). These differences are not always reflected in numbers; they often appear in the quality of participation, communication style, and distribution of responses within discussion spaces.

Research on online discussions indicates that interaction structures may relate to learners' social characteristics, including gender (Nur, Komariah, Wilodati, & Aba, 2025; Perea & Miranda, 2025). For instance, forums without clear structure may encourage more competitive participation, while structured discussion formats can support more reflective and dialogical contributions (Berhanu et al., 2026; Salam et al., 2026). In this context, gender is not treated only as a biological category, but as a social construct that can affect how individuals take part in public spaces, including digital environments. Therefore, interaction within LMS should be examined not only through contribution frequency, but also through response patterns, voice visibility, and the balance of participation among class members (Arévalo-Martínez, Vílchez-Conesa, Melguizo-Ibáñez, & Ortiz-Franco, 2026; Muharni et al., 2025).

Current approaches in educational technology place growing attention on equitable digital interaction, which refers to a condition where all learners have the same opportunity to contribute and participate meaningfully in academic dialogue (Matobobo, 2026; Perea & Miranda, 2025). This view is not based on the assumption that severe inequality always exists, but on the need to build learning systems that actively support inclusivity and balanced participation. In this regard, gender-responsive principles become relevant in LMS design because digital interaction takes place within social norms that can shape how students express ideas and respond to others (Berhanu et al., 2026). Thus, understanding the connection between gender and digital interaction is an important basis for developing LMS design principles that promote equitable participation (Ajani et al., 2025). Nevertheless, many studies on gender and online learning still concentrate on identifying differences between male and female students, while fewer explain how LMS design can help prevent unequal participation. This gap shows the need to translate gender-responsive principles into practical digital learning features that guide interaction, improve student visibility, and encourage reciprocal participation.

2.3. Gender-Responsive Instructional Design in Digital Learning Environments

The development of instructional design in digital learning has gradually moved toward approaches that are more inclusive and sensitive to context. Concepts such as inclusive instructional design and culturally responsive pedagogy highlight that learning systems do more than organize content delivery; they also influence learning experiences and the way student participation is distributed (García, Gil-Mediavilla, Álvarez, & Casares, 2020; Heilemann, Schober, Stoeger, & Ziegler, 2026). In digital settings, instructional design is not only concerned with arranging content but also with interaction structures, discussion mechanisms, participation rules, and the visual and textual representations that shape social meaning. Therefore, LMS design can affect how students position themselves and take part in online learning spaces (Ajani, Gamede, & Govender, 2025; Cheng, Yang, & Luo, 2024).

A gender-responsive approach in instructional design is not intended to provide different treatment based on sex. Instead, it seeks to ensure that system structures do not indirectly maintain unequal communication patterns (Goh & Yang, 2021; Perea & Miranda, 2025). The literature shows that open discussion structures without sufficient guidance may result in conversational dominance by certain participants. In contrast, structured designs, such as turn-taking mechanisms, reflective role assignments, and argumentation guidelines, can support a more balanced distribution of contributions (Amoak & Najjar, 2026). In this context, gender responsiveness refers to the integration of participation equity principles into the structure of digital learning, rather than an intervention based on assumptions of extreme inequality (El Ouahabi et al., 2025).

Although several studies have examined inclusive design in digital learning, many still discuss it mainly as a set of broad principles and do not clearly show how gender-responsive values can be turned into concrete LMS features (Fitrah et al., 2025; Zulherman, Mansor, & Kulgemeyer, 2025). Previous research also tends to treat inclusive pedagogy, platform usability, and student engagement as separate issues, rather than linking gender-responsive instructional design with measurable data on digital interaction (Efiloğlu Kurt, 2023; Goh, 2026). This limitation points to a clear research gap: the need to develop and validate an LMS model that combines structured discussion,

role rotation, guided prompts, participation dashboards, and learning analytics to support more equitable student interaction (Qaddumi & Smith, 2024; Sáiz-Manzanares et al., 2021).

3. Research Method

3.1. Research Design

This study employs a Research and Development (R&D) approach aimed at designing and validating a gender-responsive Learning Management System (LMS) to support equitable digital interaction in secondary education. The research design adopts the ADDIE model, which consists of five systematic stages: analysis, design, development, implementation, and evaluation (Branch, 2009). The analysis phase was used to examine learning needs and students’ patterns of digital interaction. The design phase then translated these findings into LMS principles and structures based on gender-responsive considerations. In the development phase, a prototype was created with structured discussion features. The implementation phase took place in an authentic learning setting, while the evaluation phase involved expert validation and assessment of the system’s effectiveness in improving students’ digital interaction. This approach allowed the study to combine a systematic instructional design process with empirical evaluation of system performance in a real learning environment.

3.2. Participants and Research Context

The study population consisted of upper secondary students taking Sociology courses in public senior high schools in Bandung City, Indonesia. The sample included 500 Grade XI students and 8 Sociology teachers from four schools: SMAN 1 Bandung, SMAN 5 Bandung, SMAN 7 Bandung, and SMAN 8 Bandung. Each school was represented by two teachers. These schools were chosen because they were willing to participate, had sufficient digital learning facilities, and had previously used LMS-based learning activities. The school names are provided to make the research setting clearer, improve transparency, and give a more specific picture of the participants’ institutional context.

3.3. Instruments and Data Collection

The instruments in this study were prepared to support system validation and the analysis of students’ digital interaction. First, an expert validation sheet was used to assess the LMS design in terms of system functionality, discussion structure, and the integration of gender-responsive principles. The results were analyzed using the Content Validity Index (CVI). Second, the learning analytics module in the LMS was used to record student activity logs, including contribution frequency, distribution of discussion initiations, cross-gender response ratios, degree centrality, and response reciprocity. Third, an equitable digital interaction instrument was developed to calculate the gender-based participation distribution index before and after implementation. Fourth, a user perception questionnaire was given to examine students’ experiences with the interaction structure, clarity of discussion roles, and perceived participation equity on the platform. Together, these instruments allowed the LMS to be evaluated not only for content validity but also for measurable patterns of digital participation.

3.4. Data Analysis Techniques

Data were collected step by step following the five phases of the ADDIE model. In the analysis phase, the needs assessment was carried out through preliminary observations and mapping of students’ digital interaction patterns in the LMS that had been used previously. The design and development phases focused on preparing structured discussion features and validating the LMS prototype with experts, while the Content Validity Index (CVI) was used to examine the feasibility of the design. In the implementation phase, the LMS was tested with 500 Grade XI students for eight weeks in Sociology classes. During this period, digital interaction data were recorded automatically through the learning analytics module, including contribution frequency, response distribution, degree centrality, and cross-gender response ratios. The evaluation phase involved quantitative analysis of changes in interaction patterns through pre–post comparison tests and calculation of the Digital Participation Equity Index, supported by descriptive analysis of user perceptions. Through this procedure, the system could be evaluated comprehensively in terms of both design validity and empirically measurable digital interaction dynamics.

4. Results

4.1. Analysis Phase

The analysis phase was used to identify students’ digital interaction patterns before the gender-responsive LMS was implemented. This process relied on log data from the learning analytics module. The analysis covered contribution frequency, the distribution of discussion initiations, cross-gender response ratios, and interaction network metrics. Table 1 presents the statistical summary, while Figure 1 illustrates the distribution of student contributions.

Table 1. Descriptive statistics of baseline digital interaction.

Indicator	Total	Male	Female
Mean total posts	7.92	7.86	7.98
Mean initial posts	2.98	2.95	3.01
Mean replies	4.94	4.91	4.97
Reply-to-post ratio	1.69	1.66	1.71
Mean degree centrality	0.032	0.031	0.033

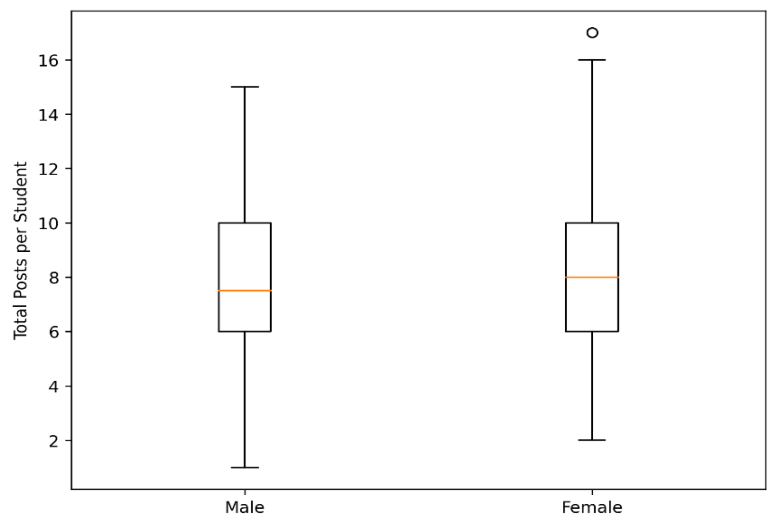


Figure 1. Distribution of total posts per student by gender at baseline.

Based on Table 1, average student contributions at the baseline stage were fairly similar between male and female students, both in total postings and discussion initiations. The cross-gender response ratio also showed almost the same values, suggesting that the initial level of dialogue did not differ substantially. The mean degree centrality value shows that the interaction network was not yet evenly distributed across class members. As shown in Figure 1, student contributions varied across individuals, with several outliers and a concentration of activity among the top 25% most active students, reaching 42.51%. These findings suggest that although gender-based participation was relatively balanced in quantitative terms, individual contribution patterns were not yet fully equitable. Therefore, design intervention was needed in the next stage.

4.2. Design Phase

The design phase focused on developing the principles and structure of a gender-responsive LMS based on the baseline results from the analysis phase. Since the initial findings showed uneven contribution patterns and the need to improve dialogue quality, the design process emphasized the restructuring of discussion mechanisms, the arrangement of participation roles, and the creation of a system to monitor contribution distribution. These design principles were formulated by combining instructional design approaches with the concept of equitable digital interaction. Table 2 summarizes the principles and their translation into LMS features, while Figure 2 presents the conceptual architecture of the system.

Table 2. Design principles and feature mapping of the gender-responsive LMS.

Design Principle	Instructional Objective	LMS Feature Implemented
Structured discussion sequencing	Enhance dialogue depth	Threaded discussion with mandatory stages (Initiation–response–reflection)
Participation visibility control	Reduce individual dominance	Individual contribution indicators displayed on the dashboard
Guided response prompts	Encourage reflective argumentation	Response templates based on guiding questions
Balanced interaction monitoring	Monitor participation distribution	Learning analytics with participation distribution reports
Role rotation mechanism	Promote equitable distribution of discussion roles	Rotational role assignment (Initiator, responder, synthesizer)

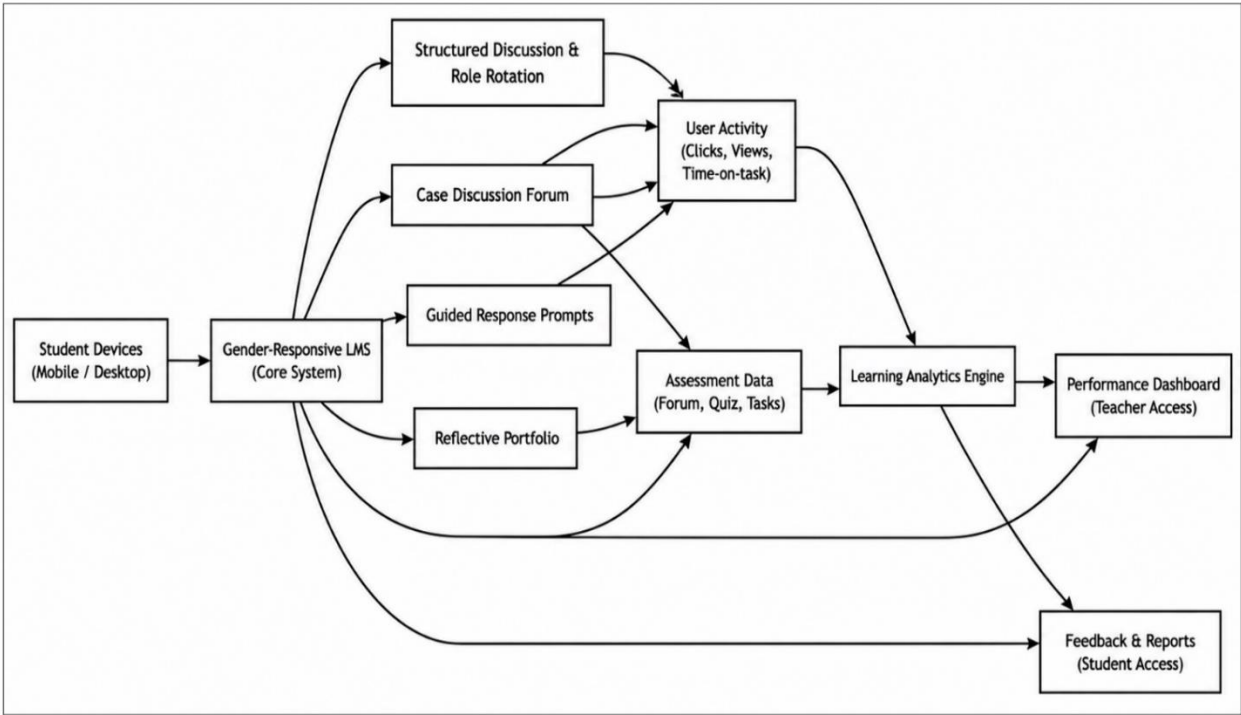


Figure 2. Conceptual architecture of the gender-responsive LMS.

Based on Table 2, the LMS design focuses on reorganizing digital interaction through structured discussion stages and rotating participation roles. The features developed in the system do not provide different treatment based on gender. Instead, they are intended to make the system structure support a more balanced distribution of participation and more reflective dialogue. The system architecture shown in Figure 2 illustrates the connection between instructional layers, interaction mechanisms, and analytics modules within one integrated system. This design phase produced an LMS prototype, which was then validated in the development phase.

4.3. Development Phase

The development phase produced the gender-responsive LMS prototype based on the conceptual architecture prepared in the design phase. The system was developed by combining structured discussion modules, an automated role rotation mechanism, a participation visibility dashboard, and a learning analytics module into one integrated platform. Each feature was functionally tested to ensure that it was consistent with gender-responsive design principles and suitable for Grade XI Sociology learning. Expert validation covering system functionality, pedagogical coherence, and the integration of participation equity principles was analyzed using the Content Validity Index (CVI). Table 3 presents the validation results, while Figure 3 shows the interface and feature integration of the LMS prototype. Overall, all main components reached the “very valid” category and were considered feasible for use in the next stage.

Table 3. Development validation results of the gender-responsive LMS.

Component Evaluated	Validation Aspect	CVI Score
Structured Discussion Module	Appropriateness of the initiation–response–reflection stages	0.92
Role Rotation System	Clarity of role distribution and automation mechanism	0.90
Participation Dashboard	Accuracy and transparency of contribution indicators	0.94
Guided Response Template	Relevance of guiding questions for argumentation	0.91
Learning Analytics Module	Accuracy of participation distribution measurement	0.93
System Integration	Consistency across modules	0.95

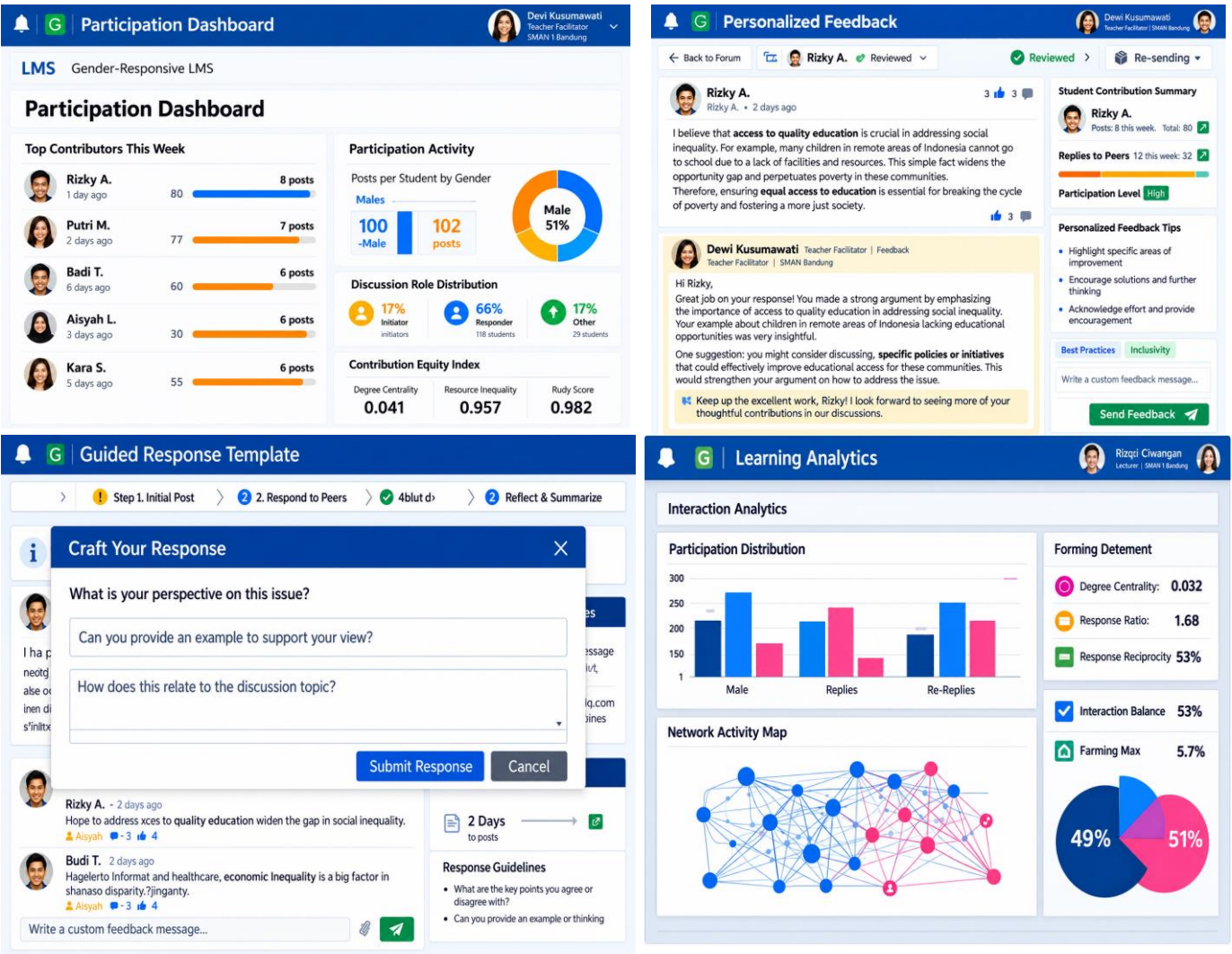


Figure 3. Interface Prototype of the Gender-Responsive LMS (Discussion & Analytics View).

Based on Table 3, all system components obtained CVI scores between 0.90 and 0.95, placing them in the “very valid” category. The highest score was found in system integration, with a CVI of 0.95. This result shows that the LMS prototype is functionally feasible, pedagogically coherent, and aligned with gender-responsive principles. Figure 3 shows how the design principles from the previous stage were applied in concrete features, including staged discussion, participation role rotation, contribution visibility, and learning analytics-based monitoring of degree centrality, response reciprocity, and interaction balance. The combination of these features shows that gender responsiveness has been translated into measurable and data-driven system mechanisms. Thus, the development phase produced an LMS that was ready to be tested in the implementation phase to examine its effectiveness in improving the equity of digital participation distribution.

4.4. Implementation Phase

The implementation phase was conducted over eight weeks with 500 Grade XI students in Sociology classes, using the gender-responsive LMS that had been validated during the development phase. The primary objective of this phase was to examine the effectiveness of the system in improving participation distribution and balancing digital interaction compared to the baseline condition. A comparison of indicators before and after implementation is presented in Table 4, while changes in contribution distribution and interaction network structure are comprehensively visualized in Figure 4. The analyzed indicators included mean total posts, reply-to-post ratio, degree centrality, response reciprocity, concentration of contributions among the top 25% most active students, and the Digital Participation Equity Index.

Table 4. Comparison of digital interaction indicators before and after implementation.

Indicator	Baseline	Post-Implementation
Mean Total Posts	7.92	8.74
Reply-to-Post Ratio	1.69	1.94
Mean Degree Centrality	0.032	0.046
Response Reciprocity	53%	68%
Top 25% Contribution (%)	42.51%	31.84%
Digital Participation Equity Index	0.71	0.89

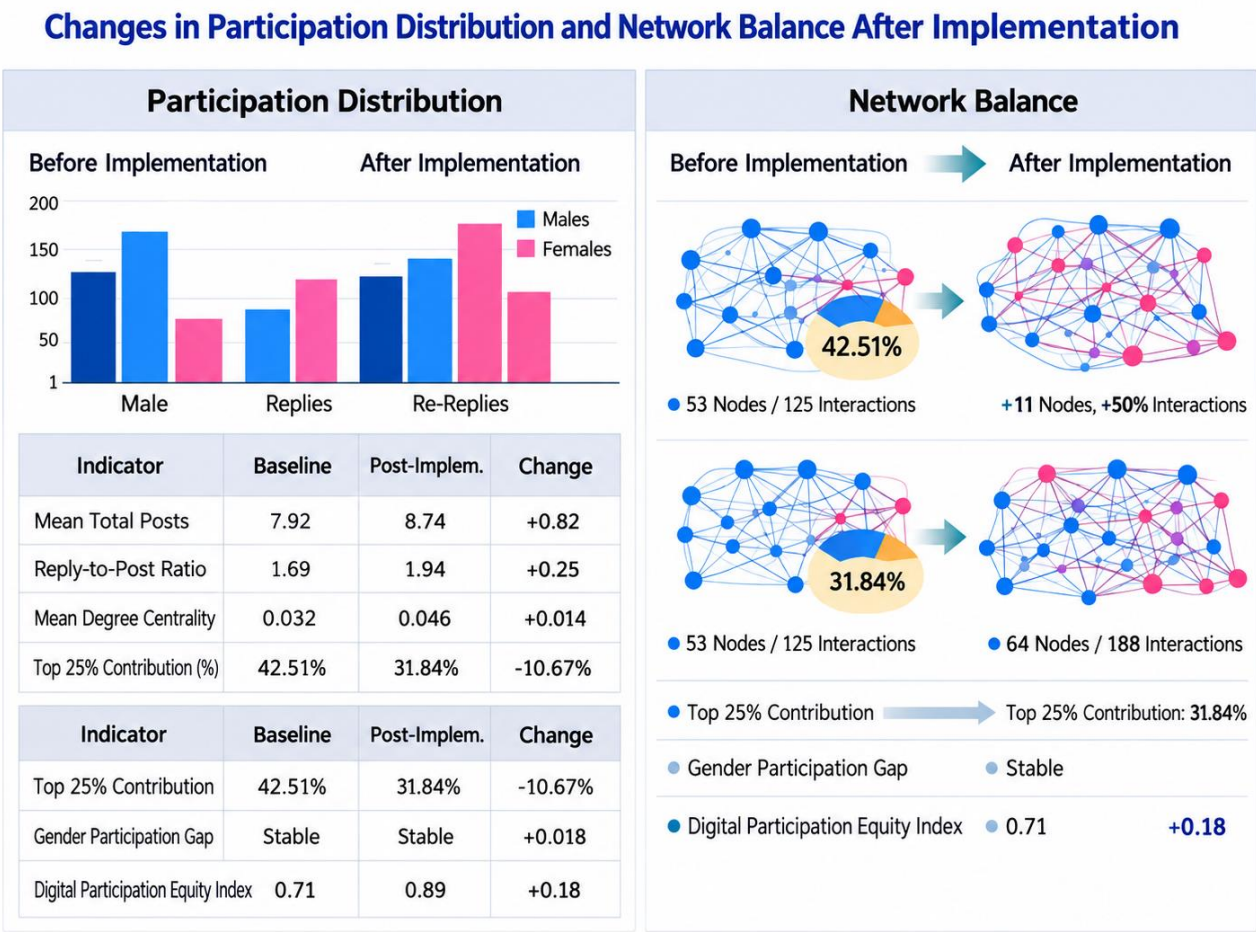


Figure 4. Changes in participation distribution and network balance after implementation.

Based on Table 4, nearly all indicators showed improvement following the implementation of the gender-responsive LMS. The average number of student contributions rose by 0.82 posts, along with an increase in the reply-to-post ratio, showing that dialogue became more active and continued more steadily. The rise in mean degree centrality from 0.032 to 0.046 indicates that the discussion network was more widely distributed and less dependent on certain individuals. A 10.67% decrease in contributions from the top 25% most active students shows that participation became less concentrated, leading to a fairer distribution of contributions. The 15% improvement in response reciprocity indicates more mutual interaction, while the increase in the Digital Participation Equity Index from 0.71 to 0.89 further shows that the system improved participation balance without producing gender-based disparities. These findings are further supported by the visualization in Figure 4, which illustrates a shift from a more centralized network pattern to a more interconnected and balanced structure after implementation. Therefore, the implementation phase provides empirical evidence that restructuring digital interaction through a gender-responsive LMS design is effective in improving the equity of contribution distribution and the quality of dialogic dynamics in secondary-level online learning.

4.5. Evaluation Phase

The evaluation phase was conducted to assess the effectiveness of the gender-responsive LMS after the eight-week implementation, following the evaluation procedures outlined in the ADDIE model. The evaluation was carried out through two approaches: (1) quantitative pre-post analysis of digital interaction indicators based on learning analytics, and (2) descriptive analysis of user perceptions regarding the structure and equity of participation within the system. The results of the quantitative analysis are presented in Table 5, while user perception results are displayed in Table 6.

Table 5. Pre-post statistical evaluation of digital interaction indicators.

Indicator	Baseline	Post	p-value	Effect Size (d)
Mean Total Posts	7.92	8.74	< 0.001	0.34
Reply-to-Post Ratio	1.69	1.94	< 0.001	0.41
Mean Degree Centrality	0.032	0.046	< 0.001	0.58
Response Reciprocity	53%	68%	< 0.001	0.62
Top 25% Contribution	42.51%	31.84%	< 0.001	0.55
Digital Participation Equity Index	0.71	0.89	< 0.001	0.67

Table 6. User perception of the gender-responsive LMS.

Dimension	Mean (1–5)	Interpretation
Clarity of discussion stages	4.32	High
Helpfulness of guided prompts	4.28	High
Role rotation fairness	4.21	High
Perceived participation equity	4.26	High
System usability	4.18	High

Based on Table 5, all indicators demonstrated statistically significant changes ($p < .001$). The increases in mean total posts and reply-to-post ratio indicate more active and sustained dialogue. The rise in degree centrality and response reciprocity suggests that the discussion network became more distributed and interactions more reciprocal. The 10.67% reduction in contributions from the top 25% most active students indicates decreased participation concentration among a small group of students. Furthermore, the increase in the Digital Participation Equity Index from 0.71 to 0.89 reinforces that the system successfully improved the equitable distribution of participation. These quantitative findings are supported by Table 6, which shows that students perceived the discussion structure, role rotation mechanism, and monitoring system as clear, fair, and easy to use. Therefore, the evaluation phase confirms that the developed gender-responsive LMS is not only valid in design and effective in implementation but also positively received by users as a system that supports more equitable digital interaction.

5. Discussion

This study shows that a Learning Management System (LMS) developed with gender-responsive principles can significantly improve the distribution of participation and the balance of digital interaction compared with conventional LMS designs. The main novel finding is that redesigning the interaction architecture through staged discussions, role rotation, guided prompts, and learning analytics-based monitoring reduced the concentration of contributions among a small group of students while also increasing reciprocity and the equity index (Perea & Miranda, 2025). Therefore, this study confirms that platform design affects participation patterns and provides empirical evidence that gender-responsive principles can be translated into measurable system mechanisms.

These findings align with studies on interaction design and equitable participation frameworks, which argue that discussion structure influences dialogue quality and the distribution of voice in online learning (Maryati et al., 2024; Pacheco et al., 2025). Earlier studies have found that unstructured forums often lead to conversational dominance and uneven participation, while discussion scaffolding can improve argumentative depth (Limonthy & Madyatmadja, 2024; Marmoah et al., 2024). However, many of these studies mainly address cognitive quality or general engagement, rather than participation distribution as a marker of structural equity. In addition, research on gender in digital learning commonly focuses on technology access or differences in communication styles, rather than positioning system design as the main intervention variable (Sousa, Marôco, Gonçalves, & Machado, 2022; Yılmaz Findık, 2025). In this regard, the present study contributes to the literature by moving the focus from individual behavior analysis to the design of interaction architecture as a preventive strategy for reducing participation inequality. Interestingly, the baseline results showed no significant difference between male and female students in average contribution levels. This finding is in line with recent studies suggesting that quantitative gender gaps in secondary education are becoming smaller. Even so, the study found that the concentration of contributions among a small group of students remained, despite the absence of clear gender-based disparities (Arévalo-Martínez et al., 2026; Herut, 2026). Therefore, this study brings an additional perspective to the discussion: equity in digital interaction should not be assessed only through gender comparisons, but also through how contributions are distributed within discussion networks (Amoak & Najjar, 2026; Sharma & Goswami, 2025). The main contribution of this research is its systematic integration of instructional design, a gender-responsive perspective, and digital network analytics as a basis for developing LMS platforms that are more inclusive and pedagogically structured.

The findings also have theoretical importance because they question the assumption that Learning Management Systems (LMS) operate as pedagogically neutral media. The increases in degree centrality, response reciprocity, and the Digital Participation Equity Index show that changes in interaction architecture directly affect the distribution of participatory power in digital discussion spaces. Thus, this study strengthens the view that educational technology is not simply a passive tool, but a socio-digital structure that shapes who becomes visible, who is connected, and who dominates academic conversations (Sari et al., 2026; Suryani et al., 2024). From an epistemological perspective, these findings broaden the discussion of instructional design by treating participation equity as a systemic variable, rather than only as an outcome of individual behavior (Perea & Miranda, 2025).

The main scientific contribution of this study is its translation of gender responsiveness into measurable and replicable, data-based indicators. Previous studies have often examined inclusivity and participation equity through normative or reflective perspectives, but only a limited number have embedded these principles into system designs evaluated through interaction network metrics and contribution distribution indices (Bures et al., 2022; Johnston et al., 2024). By integrating the ADDIE model, learning analytics, and statistical pre-post evaluation, this study shows that instructional design can serve as a structural intervention with observable effects on digital communication patterns. However, improvements in the equity index and reciprocity should not be interpreted as automatic evidence of deeper dialogue quality. A more balanced distribution of contributions may indicate wider participation, but it does

not necessarily mean that all contributions have the same epistemic depth. For this reason, future studies should examine argumentative quality more closely.

Several alternative interpretations also need to be considered critically. The increase in participation after implementation may have been partly shaped by a novelty effect or by students' increased awareness of the monitoring dashboard, rather than only by the internalization of gender-responsive principles. Contribution visibility may also create a performative form of participation, where students become active to meet quantitative indicators rather than to engage in genuine dialogic reflection. Even so, the significant decrease in contribution concentration among the top 25% most active students shows that the system helped reduce structural dominance, which was one of the main aims of this study. Therefore, the contribution of this research is not a claim of broad social transformation, but evidence that interaction architecture design can work as a preventive mechanism for regulating participation distribution more equitably in secondary education (Corrales, Rodríguez, Merchán, Merchán, & Pérez, 2024; Fahrudin & Saefudin, 2025; Ghazali, Ab. Aziz, Ab. Aziz, & Tse Kian, 2024).

Practically, this study has important implications for LMS developers and educational institutions. Instead of intervening at the individual level by using gender categories, the findings show that changes in discussion structures, such as role rotation and response sequencing, can influence participation distribution without relying on discriminatory practices or explicit categorization. This approach provides a more ethical and systemic design model for building inclusive learning environments. However, long-term use needs to consider whether the design effects can be sustained, whether users may become tired of structured mechanisms, and how the model can be adapted to other subject areas. Thus, the contribution of this study lies in a shift of perspective: from correcting individual learners to designing interaction systems that structurally support equity in digital participation.

6. Conclusion

This study shows that redesigning the interaction architecture within a Learning Management System (LMS) using gender-responsive principles can improve the distribution of digital participation without applying different treatment based on gender. The baseline results showed that, although there was no quantitative participation gap between male and female students, discussion contributions were still concentrated among a small group of students. After eight weeks of implementation, the system design, which combined discussion sequencing, role rotation, guided prompts, and learning analytics-based monitoring, led to significant increases in degree centrality, response reciprocity, and the Digital Participation Equity Index, along with a decrease in contribution concentration among the most active students. These findings support the argument discussed earlier that LMS platforms are not neutral media but socio-digital structures that can be designed to shape the distribution of voice in online learning spaces. Therefore, the aim of designing and validating a gender-responsive LMS to support equitable digital interaction has been achieved. The study also confirms its conceptual contribution by showing that participation equity is not only a matter of gender differences but also an issue of interaction system design that can be measured, tested, and developed scientifically.

7. Suggestions

Future studies should build on this research by using a control group design to provide stronger causal evidence. They should also examine not only how participation is distributed but also the quality of students' arguments and their critical thinking processes. Further research is also needed to explore how different student characteristics, including gender, interact with structured LMS features, so it can be determined whether the improvements benefit all groups equally or affect some groups more than others. Longitudinal studies would also be useful for evaluating whether the intervention effects can be sustained over time and for identifying possible issues such as user fatigue or performative participation caused by monitoring systems. Finally, clearer refinement and operationalization of key indicators, such as the Digital Participation Equity Index and interaction reciprocity, would improve the transparency, replicability, and wider applicability of gender-responsive LMS design across different educational contexts.

References

- Ajani, O. A., Gamede, B. T., & Govender, S. (2025). Cultural and ethical dimensions of learning management system adoption in rural universities: Exploring data privacy, algorithmic bias, and contextual realities. *Multidisciplinary Science Journal*, 8(3), 2026142. <https://doi.org/10.31893/multiscience.2026142>
- Ajani, O. A., Govender, S., & Gamede, B. T. (2025). Enhancing equitable and accessible learning for undergraduate students at rural universities through learning management systems: Effectiveness, challenges and optimisation. *Multidisciplinary Reviews*, 9(2), 2026098. <https://doi.org/10.31893/multirev.2026098>
- Al-Fraihat, D., Alshahrani, A. M., Alzaidi, M., Shaikh, A. A., Al-Obeidallah, M., & Al-Okaily, M. (2025). Exploring students' perceptions of the design and use of the Moodle learning management system. *Computers in Human Behavior Reports*, 18, 100685. <https://doi.org/10.1016/j.chbr.2025.100685>
- Alkhawaja, M. I., Abd Halim, M. S., Abumandil, M. S. S., & Al-Adwan, A. S. (2022). System quality and student's acceptance of the e-learning system: The serial mediation of perceived usefulness and intention to use. *Contemporary Educational Technology*, 14(2), ep350. <https://doi.org/10.30935/cedtech/11525>
- Amoak, D., & Najjar, D. (2026). Governing agrifood systems for climate resilience and gender inclusivity: A strategic review of the evidence. *Environmental Development*, 57, 101308. <https://doi.org/10.1016/j.envdev.2025.101308>
- Arévalo-Martínez, F. J., Vilchez-Conesa, P., Melguizo-Ibáñez, E., & Ortiz-Franco, M. A. (2026). A structural equation model of the mediating and moderating role of gender in the relationship between parental educational styles and emotional intelligence in physical education. *BMC Psychology*, 14(1), 66. <https://doi.org/10.1186/s40359-025-03824-4>
- Berhanu, K. Z., Ayele, W. G., & Naidoo, P. (2026). The role of teachers' language usage in the relationship between their awareness toward the concept of gender equality and gender pedagogy practice in upper primary schools. *BMC Psychology*, 14(1), 19. <https://doi.org/10.1186/s40359-025-03827-1>
- Branch, R. M. (2009). *Instructional design: The ADDIE approach*. New York, NY: Springer. <https://doi.org/10.1007/978-0-387-09506-6>
- Bures, M., Ripka, V., Buresova, K., Frajtek, K., Maha, J., & Cinatl, K. (2022). An innovative e-learning support for modern history distance learning and the experience during the COVID-19 lockdown. *Sustainability*, 14(6), 3631. <https://doi.org/10.3390/su14063631>
- Chen, L. L., Guo, Z., & Liang, Q. (2026). Gender differences in digital literacy: A systematic and meta-analytic review across developmental stages and socio-cultural contexts. *Frontiers in Psychology*, 17, 1673694. <https://doi.org/10.3389/fpsyg.2026.1673694>
- Cheng, S., Yang, Q., & Luo, H. (2024). Design of neural network-based online teaching interactive system in the context of multimedia-assisted teaching. *Informatica*, 48(7), 53–62. <https://doi.org/10.31449/inf.v48i7.5205>

- Corrales, M., Rodríguez, F., Merchán, M. J., Merchán, P., & Pérez, E. (2024). Comparative analysis between virtual visits and pedagogical outings to heritage sites: An application in the teaching of history. *Heritage*, 7(1), 366-379. <https://doi.org/10.3390/heritage7010018>
- Dobrokhoto, D. A., Sayapina, A. E., Khairullina, E. R., Khafizova, A. A., Prokopyev, A. I., & Erokhova, N. S. (2025). Exploring gender in ICT integrated STEM education: A bibliometric study. *Contemporary Educational Technology*, 17(3), ep589. <https://doi.org/10.30935/cedtech/16741>
- Efiloglu Kurt, Ö. (2023). Learning with smartphones: The acceptance of m-learning in higher education. *Online Information Review*, 47(5), 862-879. <https://doi.org/10.1108/OIR-10-2021-0516>
- El Ouahabi, F. Z., Essaoudi, H., Fattari, A., Hamdane, K., Abbassi, S., El Bouzaidi, R. D., & Chaiba, A. (2025). Primary pre-service teachers' self-efficacy beliefs in integrating gender approaches: Relationship with demographic profiles. *Frontiers in Education*, 10, 1532294. <https://doi.org/10.3389/feduc.2025.1532294>
- Fahrudin, F., & Saefudin, A. (2025). Primary sources in online history learning: Enhancing engagement and retention. *Cogent Education*, 12(1), 2452087. <https://doi.org/10.1080/2331186X.2025.2452087>
- Fitrah, M., Setiawan, C., Widiastuti, W., Sofroniou, A., Rahmawati, N. A., Arina, A., . . . Iskandar, I. (2025). Impact of learning management systems and digital skills on TPACK development among pre-service mathematics teachers. *Qubahan Academic Journal*, 5(1), 504-518. <https://doi.org/10.48161/qaj.v5n1a1392>
- García, A. C., Gil-Mediavilla, M., Álvarez, I., & Casares, M. d. I. Á. (2020). The influence of social networks within educational and social fields: A comparative study between two generations of online students. *Sustainability*, 12(23), 9941. <https://doi.org/10.3390/su12239941>
- Ghazali, A. K., Ab. Aziz, N. A., Ab. Aziz, K., & Tse Kian, N. (2024). The usage of virtual reality in engineering education. *Cogent Education*, 11(1), 2319441. <https://doi.org/10.1080/2331186X.2024.2319441>
- Goh, T.-T. (2026). Learning management system log analytics: The role of persistence and consistency of engagement behaviour on academic success. *Journal of Computers in Education*, 13(1), 283-306. <https://doi.org/10.1007/s40692-025-00358-x>
- Goh, T.-T., & Yang, B. (2021). The role of e-engagement and flow on the continuance with a learning management system in a blended learning environment. *International Journal of Educational Technology in Higher Education*, 18(1), 49. <https://doi.org/10.1186/s41239-021-00285-8>
- Handayani, T., Tiara, M. A., Mansor, A. B. A., & Zulherman. (2025). Effectiveness of using learning management system for pre-service primary school teachers. *Multidisciplinary Science Journal*, 8(3), 2026148. <https://doi.org/10.31893/multiscience.2026148>
- Heilemann, M., Schober, S., Stoeger, H., & Ziegler, A. (2026). Extending STEM identity to the institutional level: How organizational identity and efficacy shape gender-inclusive practice in out-of-school education. *International Journal of STEM Education*, 13(1), 5. <https://doi.org/10.1186/s40594-026-00595-1>
- Herut, A. H. (2026). Exploring the pursuit of knowledge in gender-inclusive pedagogy: A bibliometric analysis of scholarly contributions towards achieving sustainable development goals. *Discover Education*, 5(1), 134. <https://doi.org/10.1007/s44217-026-01181-x>
- Ibrahim, A., Ermatita, & Saparudin. (2022). Social customer relationship management as a communication tool for academic communities in higher education institutions through social media. *International Journal of Advanced Computer Science and Applications*, 13(5), 401-411. <https://doi.org/10.14569/IJACSA.2022.0130548>
- Ingvakara, T., Panjaburee, P., Srisawasdi, N., & Sajjanaroj, S. (2022). The use of a personalized learning approach to implementing self-regulated online learning. *Computers and Education: Artificial Intelligence*, 3, 100086. <https://doi.org/10.1016/j.caeai.2022.100086>
- Johnston, H., Wells, R. F., Shanks, E. M., Boey, T., & Parsons, B. N. (2024). Student perspectives on the use of generative artificial intelligence technologies in higher education. *International Journal for Educational Integrity*, 20(1), 2. <https://doi.org/10.1007/s40979-024-00149-4>
- Komariah, S., Amanah, D. A., & Mujayapura, M. R. R. (2025). Sundanese women in politics: A structural analysis to inform educational strategies for gender equality. *Jurnal Cakrawala Pendidikan*, 44(2), 413-424. <https://doi.org/10.21831/cp.v44i2.82057>
- Limonthy, S., & Madyatmadja, E. D. (2024). Factors influencing student individual performance of university XYZ through the use of mobile learning management system. *Journal of Computer Science*, 20(3), 276-290. <https://doi.org/10.3844/jcssp.2024.276.290>
- Marmoah, S., Sukmawati, F., Poerwanti, J. I. S., Supianto, Yantoro, & Nafisaha, A. (2024). The level of teacher creativity in developing digital learning materials on learning management system. *Pakistan Journal of Life and Social Sciences*, 22(2), 3103-3118. <https://doi.org/10.57239/PJLSS-2024-22.2.00227>
- Maryati, I., Fisher, D., Mohd Yatim, S. A., & Mauladaniyati, R. (2024). Statistical literacy ability of students through virtual learning environment based on Moodle-learning management system. *International Journal of Information and Education Technology*, 14(1), 99-106. <https://doi.org/10.18178/ijiet.2024.14.1.2029>
- Matobobo, C. (2026). A systematic review of gender differences in students' use of AI tools for learning in higher education. *Discover Education*, 5(1), 90. <https://doi.org/10.1007/s44217-026-01116-6>
- Muharni, A., Mahanal, S., Zubaidah, S., & Susanto, H. (2025). Implementation and empirical analysis of ACCA model optimized by learning management system to enhance the students' creative thinking skills. *JOIV: International Journal on Informatics Visualization*, 9(4), 1493-1502. <https://doi.org/10.62527/joiv.9.4.3417>
- Muhmad Asri, F. H., Singh, D., Mansor, Z., & Norman, H. (2024). A review of cross-cultural design to improve user engagement for learning management system. *KSII Transactions on Internet and Information Systems*, 18(2), 397-419. <https://doi.org/10.3837/tiis.2024.02.007>
- Nur, R. J., Komariah, S., Wilodati, & Aba, A. (2025). Achieving equality through education as a response to gender stereotypes in women: A quantitative analysis. *Review of Integrative Business and Economics Research*, 14(1), 382-392.
- Pacheco, A., Yupanqui, R., Mogrovejo, D., Garay, J., & Uribe-Hernández, Y. (2025). Impact of digitization on educational management: Results of the introduction of a learning management system in a traditional school context. *Computers in Human Behavior Reports*, 17, 100592. <https://doi.org/10.1016/j.chbr.2025.100592>
- Perea, R. V., & Miranda, A. M. (2025). User acceptance of the gender and development mobile app with a rating checklist using a modified technology acceptance model. *IAES International Journal of Artificial Intelligence*, 14(5), 3906-3914. <https://doi.org/10.11591/ijai.v14.i5.pp3906-3914>
- Qaddumi, H. A., & Smith, M. (2024). Implementation of learning management systems (Moodle): Effects on students' language acquisition and attitudes towards learning English as a foreign language. *Trends in Higher Education*, 3(2), 260-272. <https://doi.org/10.3390/higheredu3020016>
- Sáiz-Manzanares, M. C., Marticorena-Sánchez, R., Rodríguez-Díez, J. J., Rodríguez-Arribas, S., Díez-Pastor, J. F., & Ji, Y. P. (2021). Improve teaching with modalities and collaborative groups in an LMS: An analysis of monitoring using visualisation techniques. *Journal of Computing in Higher Education*, 33(3), 747-778. <https://doi.org/10.1007/s12528-021-09289-9>
- Salam, A., Alam, F., Shah, D., Rahman, S. U., Ali, S., & Tahir, M. (2026). Improving cognitive stress classification via multimodal EEG and ECG fusion: Gender differences in physiological response. *Scientific Reports*, 16, 7304. <https://doi.org/10.1038/s41598-026-38356-3>
- Sari, R. P., Md Fudzee, M. F., Witarasyah, D., Kasim, S., Arshad, M. S., & Gusman, T. (2026). Exploring the impact of gamification elements in learning management systems on intrinsic and extrinsic student motivation: A systematic literature review. *JOIV: International Journal on Informatics Visualization*, 10(1), 321-334. <https://doi.org/10.62527/joiv.10.1.5141>
- Sharma, M., & Goswami, I. (2025). Multivariate decomposition of gender differentials in cognitive impairment among older adults in India based on Longitudinal Ageing Study in India, 2017-2018. *BMC Psychiatry*, 25(1), 385. <https://doi.org/10.1186/s12888-025-06811-6>
- Sorina, G. V. (2024). Logical and methodological foundations of teaching humanities in the system of higher education. *Filosofiya. Zhurnal Vysshey Shkoly Ekonomiki*, 8(1), 54-66.
- Sousa, M. J., Marôco, A. L., Gonçalves, S. P., & Machado, A. d. B. (2022). Digital learning is an educational format towards sustainable education. *Sustainability*, 14(3), 1140. <https://doi.org/10.3390/su14031140>
- Suryani, M., Sensuse, D. I., Santoso, H. B., Aji, R. F., Hadi, S., Suryono, R. R., & Kautsarina. (2024). An initial user model design for adaptive interface development in learning management system based on cognitive load. *Cognition, Technology & Work*, 26(4), 653-672. <https://doi.org/10.1007/s10111-024-00772-8>

- Utami, I. Q., Fakhruzzaman, M. N., Fahmiyah, I., Masduki, A. N., & Kamil, I. A. (2021). Customized moodle-based learning management system for socially disadvantaged schools. *Bulletin of Electrical Engineering and Informatics*, 10(6), 3325-3332. <https://doi.org/10.11591/eei.v10i6.3202>
- Yılmaz Fındık, L. (2025). Gender equality in Türkiye: A critical analysis and action plan for schools. *European Journal of Sustainable Development Research*, 9(4), em0318. <https://doi.org/10.29333/ejosdr/16578>
- Zulherman, Z., Mansor, A. B. A., & Kulgemeyer, C. (2025). The effect of convenience and self-efficacy on the satisfaction of learning management system usage. *International Journal of Evaluation and Research in Education*, 14(2), 910-917. <https://doi.org/10.11591/ijere.v14i2.32065>