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Evaluating usability, accessibility, and persuasion in learning management systems

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ABSTRACT

Learning management systems (LMSs) are widely adopted in engineering education to support content delivery, foster collaboration, and develop digital competencies. However, existing platforms often prioritize functionality over user engagement and accessibility. There is limited research that holistically evaluates LMS usability, persuasive design, and accessibility in the context of technical education, particularly during high-frequency tasks such as assignment submission. This study aims to evaluate and compare the usability, persuasive elements, and accessibility of blackboard, canvas, and Google Classroom during the assignment submission process from the perspective of engineering students. An experimental, between-subjects design was employed with engineering students who each interacted with one of the three LMS platforms. We evaluated usability, persuasiveness and accessibility. Canvas was the most efficient platform, with shorter task completion times and fewer errors. However, it received lower scores in satisfaction and persuasive design compared to Google Classroom, which stood out in credibility and user guidance but showed more variability in efficiency. None of the platforms fully complied with key accessibility criteria, such as keyboard operability and proper form labeling. These findings highlight the importance of designing LMS platforms that balance usability, persuasion, and accessibility to better support engagement and equity in engineering education.

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1. INTRODUCTION

Learning management systems (LMS) have become essential tools in modern engineering education, providing digital environments to deliver academic content, manage student activities, and foster interactions. These platforms grant students access to technical resources such as videos, tutorials, databases, and academic articles, while supporting synchronous and asynchronous collaboration [1], [2].

Beyond content delivery, LMS platforms play a crucial role in the development of digital competencies required by engineering students, including problem-solving, communication, and collaborative skills [3], [4].

Their integration into higher education has accelerated, particularly following the global shift to remote and hybrid learning models.

While LMS adoption continues to grow, the success of these platforms depends heavily on their usability and capacity to engage and motivate students. Usability—defined through metrics such as ease of use, efficiency, and user satisfaction—has been widely evaluated using tools like the system usability scale (SUS) and the User experience questionnaire (UEQ-S) [5], [6].

However, recent studies emphasize that beyond usability, the persuasive capabilities of LMS platforms—their ability to positively influence student behavior, motivation, and engagement—are equally vital for enhancing the learning experience [7], [8]. Despite this, empirical evaluations of persuasive strategies in LMSs remain limited, particularly in engineering education.

Existing research has typically focused on isolated platforms or single evaluation dimensions. For instance, comparative usability studies of blackboard, Canvas, and Google Classroom have highlighted mixed results in terms of efficiency, user satisfaction, and technical features [9], [10]. Moreover, while some studies apply heuristic frameworks such as Nielsen's usability principles [10], the integration of persuasion theory, such as the persuasive systems design (PSD) model [8], is rarely explored in parallel.

To address this gap, the present study conducts a comparative evaluation of three widely used LMS platforms: blackboard, canvas, and Google Classroom. The evaluation focuses on a core academic task—assignment submission—and simultaneously analyzes usability (efficiency, effectiveness, satisfaction) and persuasive design, based on established heuristics and the PSD model.

Furthermore, accessibility considerations were included through a checklist derived from WCAG 2.1, acknowledging the importance of equitable and inclusive design in educational technology.

The findings of this study aim to provide actionable insights into how LMS platforms can be optimized to support both task performance and student engagement in engineering programs. Statistical analyses, including the Kruskal-Wallis H test, were applied to assess the significance of observed differences [11].

Unlike previous studies that focus primarily on usability or user satisfaction, this work integrates three complementary perspectives: usability, accessibility, and persuasive design. By evaluating blackboard, canvas, and Google Classroom through the same academic task, the study provides a comparative view of how LMS platforms support engineering students in completing routine but critical learning activities. The findings aim to inform the design and selection of LMS platforms that are not only efficient, but also engaging, accessible, and supportive of equitable digital learning experiences.

Assignment submission was selected as the evaluation task because it represents one of the most frequent and essential interactions between students and LMS platforms. This task requires students to navigate course content, locate an activity, upload a file, confirm submission, and interpret system feedback. Therefore, it provides a suitable scenario for examining usability, accessibility, and persuasive design features within a realistic academic workflow.

The remainder of this paper is structured as follows. Section 2 reviews the related work on LMS usability, persuasive design, and accessibility. Section 3 describes the research methodology, including details of participants, instruments, and evaluation process. Section 4 presents the results of the empirical and heuristic evaluation, organized by usability, accessibility, and persuasion dimensions. Section 5 discusses the key findings in the context of engineering education. Finally, section 6 provides the conclusions, implications, and directions for future research.

2. RELATED WORK

LMS are digital platforms designed to support, manage, and enhance the teaching and learning process. They provide online spaces for accessing academic materials, organizing activities, and facilitating interaction between students and instructors [1], [5], [12]. The integration of LMS platforms in higher education is especially relevant in engineering programs, where they contribute to the development of technical competencies, problem-solving skills, and collaborative learning abilities [3], [4], [13].

The success of LMS platforms depends significantly on their usability, commonly evaluated through indicators such as efficiency, effectiveness, and user satisfaction. Tools like the SUS and the UEQ-S are frequently used to assess these dimensions [5], [14]-[16]. Various studies have explored the usability of LMSs in different educational contexts. For instance, [17] and [18] assessed Google Classroom's usability, reporting positive student perceptions regarding ease of use. Comparative studies have analyzed platforms such as

blackboard, Desire2Learn, Microsoft Teams, and Google Classroom, highlighting differences in satisfaction, efficiency, and error rates [16], [19].

Although previous comparative studies have evaluated multiple LMS platforms [20], most have focused exclusively on usability metrics such as satisfaction or perceived ease of use. Consequently, other dimensions that influence students' interaction, including accessibility and persuasive design, remain largely unexplored [10].

Beyond usability, the persuasive design of LMS platforms plays a crucial role in fostering student motivation, engagement, and behavioral change. Persuasive educational systems are interactive environments that incorporate strategies to support users in forming, modifying, or reinforcing learning-related attitudes and behaviors [21], [22]. However, most of these studies evaluate persuasive mechanisms in isolation rather than together with usability and accessibility. As a result, little is known about how these dimensions complement one another when students perform authentic academic tasks within LMS environments [23].

The PSD model [8] is widely used to analyze and structure persuasive strategies. This model categorizes strategies into four groups: primary task support, dialogue support, system credibility, and social support. Research applying the PSD model to LMS evaluations has highlighted that while systems often perform well in credibility-related aspects, social support strategies are frequently underutilized [24].

In addition to usability and persuasive design, LMS platforms differ in the tools and functionalities they offer for academic management and student interaction. Table 1 summarizes key features of blackboard learn, canvas, and Google Classroom, which may influence the user experience.

Table 1. Comparison of core features in three LMS platforms

Feature	Blackboard learn	Canvas LMS	Google Classroom
Course creation and editing	Yes	Yes	Yes
Assignment submission	Yes (multiple formats)	Yes (multiple formats)	Yes
Grade center and feedback	Yes	Yes	Yes
Calendar and scheduling	Yes	Yes	Yes
Integrated communication tools	Announcements, messages	Announcements, discussions	News
Synchronous video integration	Yes	Yes	Yes
Discussion or collaboration spaces	Forums	Groups	–
Course content organization	Modules, pages	Modules, folders	Themes

Although usability, accessibility, and persuasive design have each been investigated in previous LMS research, they have generally been studied as independent dimensions. Most usability studies focus on task performance and user satisfaction, accessibility evaluations concentrate on compliance with standards such as WCAG, while persuasive design research emphasizes motivation and engagement. Consequently, there is limited understanding of how these complementary dimensions interact when students perform authentic academic tasks within LMS.

Despite the growing body of research on LMS, several limitations remain. First, most comparative studies focus primarily on traditional usability metrics, such as efficiency, effectiveness, or user satisfaction, while overlooking complementary dimensions such as accessibility and persuasive design. Second, previous investigations frequently evaluate these aspects independently, making it difficult to understand how they jointly influence students' interaction with LMS platforms. Third, most studies assess general LMS usage or rely exclusively on perception-based questionnaires, with relatively few employing task-based evaluations centered on authentic academic activities. Finally, comparative evaluations conducted specifically with engineering students remain scarce, despite the intensive use of LMS platforms in engineering education. These limitations highlight the need for a more comprehensive evaluation framework integrating usability, accessibility, and persuasive design within a realistic educational context [25].

This study contributes to closing this gap by conducting a comparative evaluation of three widely used LMS platforms: blackboard learn, canvas, and Google Classroom. The analysis focuses on a critical academic task—assignment submission—and considers usability, persuasive design, and accessibility, providing actionable insights for enhancing LMS effectiveness in engineering programs.

3. METHOD

This section presents the methodology of the experiment conducted with users to evaluate the LMSs. We perform a usability analysis that evaluates effectiveness, efficiency, and satisfaction.

3.1. Research design

This research conducted a mixed-method approach because it combined quantitative measures obtained from task performance (completion time, errors, assistance requests, and SUS scores) with qualitative observations and heuristic evaluations of persuasive design and accessibility. This approach enabled a comprehensive assessment of the three LMS platforms from complementary perspectives. The study design was between subjects, where different participants evaluated each platform to avoid bias and learning.

3.2. Use cases definition

Assignment submission was selected because it represents one of the most frequently executed academic tasks across virtually all LMS. Unlike quizzes, forums, or grading modules, assignment submission is a core functionality available in blackboard, canvas, and Google Classroom. This task requires users to navigate the interface, locate course resources, upload files, confirm actions, and interpret system feedback, making it an appropriate representative task for evaluating usability, accessibility, and persuasive design. The Table 2 shows the description of the use cases. The generic steps and the specific steps for each platform show that the process is similar on the three platforms.

Table 2. Use case comparison: submitting an assignment as a student

Step	Blackboard learn	Canvas LMS	Google Classroom
Login to the platform	Login via university portal	Login to canvas	Login with Google account
Navigate to course	Go to courses	Select from dashboard	Select course
Access assignment section	Assignments or content	Assignments tab	Classwork tab
Select assignment	Choose assignment	Select assignment	Open assignment
Attach or upload file	Upload from device	Use start assignment and upload	Add or create and attach
Add optional comment	Optional text box available	Comment box available	Optional comment to teacher
Submit assignment	Click submit	Click submit assignment	Click turn in
View confirmation	Confirmation message	Confirmation with timestamp	Visual confirmation shown

Figure 1 represents a UML diagram of the process of entering the LMS and confirming the submission of a file. For the description of the process in Figure 1, an expert user is considered the profile of a student who has already had access to and training in the LMS. However, response times, methodological follow-up, and the overall analysis of the LMS comparison change based on this knowledge base.

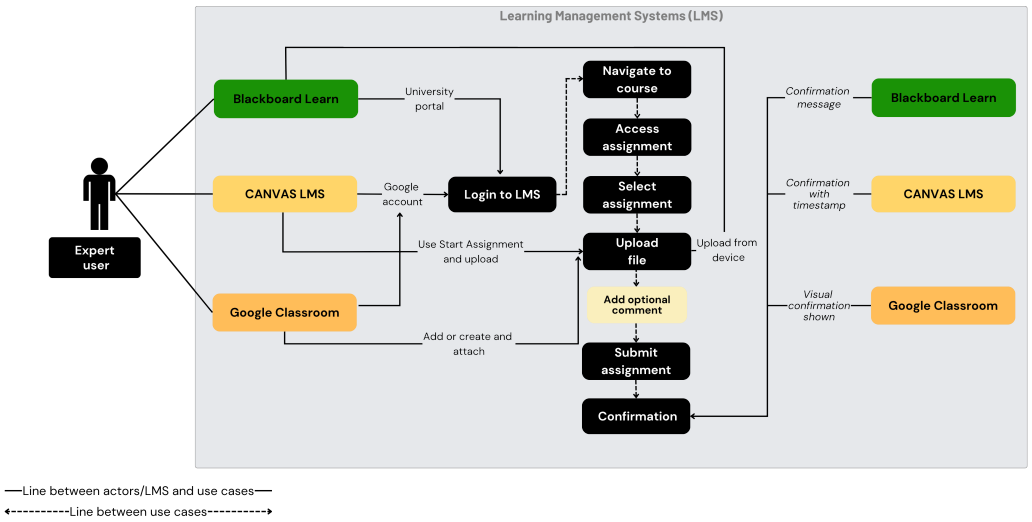


Figure 1. Workflow of the assignment submission task

3.3. Participants

A total of 17 volunteers participated in this study, the study uses a convenience sampling technique. All participants were undergraduate engineering students recruited from a public university in northwestern Mexico. Participation was voluntary, and informed consent was obtained from all participants prior to the experiment. The study followed a between-subjects design, in which each participant evaluated only one LMS platform to avoid learning effects and carry-over bias associated with repeated exposure to multiple systems.

The participant characteristics for the three LMS groups are presented in Table 3. The blackboard group consisted of participants with heterogeneous backgrounds, including both experienced and first-time users, as well as varying levels of computer proficiency. In contrast, participants assigned to canvas reported frequent computer use, although only one participant had previous experience with the platform. Participants evaluating Google Classroom also reported previous experience with digital learning environments, although none had extensive experience with the specific assignment submission workflow used during the experiment.

Table 3. Participant characteristics

Characteristic	Blackboard	Canvas	Classroom
Participants (n)	7	5	5
Female	4	1	4
Male	3	4	1
Age range	18–53	20–23	21–48
Previous experience with LMS	Mixed	Limited–Moderate	Moderate
Computer proficiency	Mixed	High	High

*Approximate range based on participant records.

Because the study focused exclusively on engineering students, the findings should be interpreted within this context. Engineering students typically possess higher levels of digital literacy than the general university population, which may influence task performance and perceived usability. Therefore, the results should not be generalized to students from other academic disciplines without further empirical validation.

Participants were assigned to one of the three LMS platforms according to platform availability while ensuring that each participant interacted with only one platform throughout the experiment.

3.4. Instruments

The instruments were selected to provide a multidimensional evaluation of the same assignment submission workflow. Rather than assessing usability, accessibility, and persuasive design as independent system attributes, the study integrated objective performance measures, subjective user perceptions, and expert inspection within a common methodological framework. The task observation sheet captured efficiency and effectiveness through completion time, errors, and assistance requests, while the SUS measured participants' perceived usability and satisfaction. The persuasive design template examined how students perceived the presence of strategies intended to guide, motivate, and sustain interaction, whereas the WCAG 2.1 checklist assessed whether the same workflow supported accessible and inclusive interaction. By applying these instruments to the same task and platforms, the methodology enabled triangulation across behavioral, perceptual, persuasive, and accessibility-related evidence, providing a more comprehensive evaluation than any single instrument could offer.

3.4.1. Task observation sheet

A structured task observation sheet was designed to record participants' performance during the experimental task. The instrument was completed by two evaluators who independently observed each participant throughout the experiment. The observation sheet included task completion time for each attempt, the number of errors, and the number of assistance requests.

Task completion time was measured in seconds from the moment participants initiated the assignment submission process until the confirmation message was displayed. Errors were defined as deviations from the expected task flow (e.g., selecting an incorrect menu option or attempting to upload an incorrect file). Assistance was recorded whenever participants explicitly requested help or clarification from the evaluators.

3.4.2. System usability scale

User satisfaction was measured using the SUS, a standardized questionnaire composed of ten items rated on a five-point Likert scale. SUS provides a global measure of perceived usability ranging from 0 to 100,

where higher scores indicate better perceived usability. The questionnaire was administered immediately after participants completed the fifth task repetition.

3.4.3. Persuasive design evaluation

The persuasive characteristics of each LMS were evaluated using the heuristic inspection method proposed by Jiménez *et al.* [26], which is based on the PSD model. The instrument evaluates persuasive strategies grouped into four categories: primary task support, dialogue support, system credibility, and social support.

Each persuasive strategy was rated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), according to the extent to which participants perceived the strategy to be implemented in the interface. Participants were also encouraged to provide qualitative observations to support their ratings.

3.4.4. Accessibility checklist

Accessibility was evaluated manually using a checklist derived from eight success criteria of the web content accessibility guidelines (WCAG) 2.1. The selected criteria focused on the assignment submission workflow and covered the four WCAG principles: perceivable, operable, understandable, and robust.

The inspection was performed by two evaluators, who independently verified compliance with each criterion during task execution. The evaluation focused on practical accessibility aspects such as keyboard navigation, alternative text, form labels, color contrast, focus order, error identification, instructions, and semantic definition of interface elements.

3.5. Procedure

The experiment was conducted in person. The researchers first explained the task the participants needed to complete, as well as the specific platform they would be using. All participants performed the task on a laptop running the Windows operating system and a stable internet service connection, equipped with an external mouse and keyboard to ensure a more comfortable and controlled interaction with the system.

Each participant completed the task five times. The completion time was recorded for each attempt, and the average time per participant was calculated for analysis. In addition to task timing, the researchers documented the number of errors and instances of assistance required. An error was defined as any deviation from the optimal task flow (e.g., clicking an incorrect menu option or uploading the wrong file). Assistance was recorded whenever participants requested help. Two evaluators observed each participant in real time and recorded observations using a standardized evaluation form. To maintain consistency between trials, participants submitted the same mock assignment in the five repetitions. Upon completing the final attempt, participants were asked to complete the SUS via a digital form to assess their general satisfaction with the platform.

3.6. Data analysis

Descriptive statistics (mean and standard deviation) were calculated for all quantitative variables. Boxplots were generated to visualize the distribution of task completion times across platforms. Since the sample size was small and the assumptions of normality could not be guaranteed, differences between groups were analyzed using the Kruskal–Wallis H test with a significance level of $p = 0.05$.

4. RESULTS

This section presents the empirical findings of the comparative evaluation of blackboard, canvas, and Google Classroom. Results are organized according to the three evaluation dimensions considered in this study: usability, accessibility, and persuasive design.

4.1. Usability evaluation

The analysis is structured around the three dimensions of usability as defined in ISO 9241-11: efficiency, effectiveness, and satisfaction.

4.1.1. Efficiency

Task efficiency was measured as the average time (in seconds) taken to complete the defined use case in five repetitions per participant. The findings present an analysis at the group level rather than per individual because the study design was between subjects.

Figure 2 shows a box plot that compares completion times between platforms. Participants using canvas achieved the fastest average completion time (M = 29.24s, SD = 7.08), followed by those using blackboard (M = 41.36s, SD = 24.46). The classroom group showed the slowest and most variable performance (M = 76.50s, SD = 57.14), with some participants taking significantly longer than others.

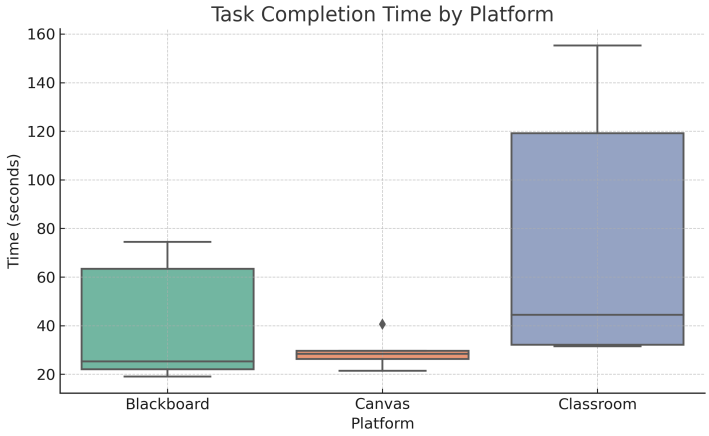


Figure 2. Task completion time by platform (seconds)

Task efficiency was measured as the average time (in seconds) required to complete the assignment submission task across five repetitions. Figure 2 compares the completion times obtained for the three evaluated LMSs.

Participants using canvas obtained the lowest average completion time (M = 29.24 s, SD = 7.08), followed by blackboard (M = 41.36 s, SD = 24.46). Google Classroom presented the highest average completion time (M = 76.50 s, SD = 57.14), with greater variability among participants.

A Kruskal-Wallis test was performed to compare completion times across the three platforms. The analysis yielded H(2)=4.07 (p=0.131), indicating that no statistically significant differences were found among the evaluated LMS. Because the study followed a between-subjects design, results are reported at the group level.

4.1.2. Effectiveness

The effectiveness was measured by recording the number of errors and assistance requests made by the participants while completing the use case. Table 4 shows the average number of errors and assistance requests per platform.

Table 4. Effectiveness results: errors and assistance requests per platform

Platform	Mean errors	SD	Mean assistance	SD
Blackboard	0.57	0.79	0.71	1.25
Canvas	0.24	0.17	0.00	0.00
Classroom	0.60	0.55	0.80	1.10

Canvas presented the lowest average number of errors (M=0.24) and no participant requested assistance during the task. Blackboard and classroom showed similar average error rates (0.57 and 0.60, respectively), whereas classroom presented the highest average number of assistance requests (M=0.80).

4.1.3. Satisfaction

User satisfaction was measured using the SUS. Table 5 presents the descriptive statistics for each platform. Participants rated canvas the highest in terms of usability, with a mean SUS score of 82.6 and low variability between participants, suggesting consistent satisfaction. Classroom had a slightly lower average (M = 76.5) but showed greater variability, including a relatively low score (42.5). Blackboard showed the lowest satisfaction (M = 61.1), with a wider spread of responses ranging from 37.5 to 80.

Table 5. Descriptive statistics of SUS scores by platform

Platform	Mean	SD	Min	Max
Blackboard	61.07	13.98	37.5	80.0
Canvas	82.60	3.97	78.0	88.0
Classroom	76.50	21.11	42.5	97.5

According to the SUS interpretation guidelines, canvas falls within the excellent usability range, classroom within the good range, and blackboard within the OK range.

4.2. Accessibility evaluation

Accessibility compliance was evaluated using the WCAG 2.1 checklist described in section 3. Table 6 summarizes the compliance of the three LMSs with the selected criteria. Blackboard and canvas complied with all evaluated criteria, whereas Google Classroom showed partial compliance in five of the eight evaluated criteria, mainly related to alternative text, keyboard navigation, focus order, and form labeling.

Table 6. Accessibility compliance checklist (WCAG 2.1) for assignment submission task (BB = Blackboard, CV = Canvas, and GC = Classroom)

Nº	WCAG 2.1 Criterion	Description	BB	CV	GC
1	1.1.1 Non-text content (A)	All icons or buttons used to upload files must have accessible alternative text or labels for screen readers.	x	x	Partially (some buttons lack alt text)
2	1.3.1 Info and relationships (A)	Input fields must be properly labeled for assistive technologies.	x	x	Partially (not all labels are programmatically defined)
3	1.4.3 Contrast (Minimum) (AA)	Text and buttons must maintain sufficient contrast.	x	x	x
4	2.1.1 Keyboard (A)	Fully operable via keyboard only.	x	x	Does not fully support keyboard-only navigation
5	2.4.3 Focus order (A)	Logical navigation sequence is maintained.	x	x	Focus jumps or skips in some views
6	3.3.1 Error identification (A)	Clear error messages when mistakes are made.	x	x	Limited
7	3.3.2 Labels or instructions (A)	Clear, visible instructions on how to upload tasks.	x	x	Instructions are minimal
8	4.1.2 Name, role, value (A)	Interactive elements must be correctly defined for assistive technologies.	x	x	Some roles/values missing or incorrectly mapped

4.3. Persuasion evaluation

This subsection presents the results of the perceived persuasiveness evaluation of the three LMS platforms, structured according to the four categories of the PSD model. A structured template based on the PSD model was used to assess the extent to which students perceived the presence of persuasive strategies in each system's interface. A 5-point Likert scale was used for this purpose (1 = Strongly disagree to 5 = Strongly agree). The maximum possible score was 125 points, derived from the sum of all evaluated strategies across the four PSD categories.

Table 7 presents the evaluation results of three LMS: blackboard, classroom, and canvas. The answers are organized according to the persuasive strategies used, grouped into four main categories based on the PSD model: primary task support, dialogue support, system credibility support, and social support.

The total possible score for the assessment was 125 points. The closer the total score of the LMS is to this value, the greater the perceived persuasiveness from the students' perspective. Figure 3 presents the overall score of each system. The results showed that classroom is in first place, blackboard second, and canvas third. In Figure 4, we present scores according to each category to emphasize where the LMS is most prominent.

The primary task support category evaluates how effectively the LMS simplifies the target behavior by providing guidance, personalization, or mechanisms to practice the required actions. In this category, classroom scored highest (23/30), followed by blackboard (17/30) and canvas (12/30), indicating a more effective implementation of reduction and guidance strategies in classroom. Students agreed that Tunneling and Reduction strategies are implemented across the three assessed LMSs, whereas simulation is less emphasized.

The dialogue support category encompasses the communication between the LMS and the student, involving feedback and encouragement mechanisms such as prizes, rewards, reminders, among others. The scores from highest to lowest are: classroom (19/30), blackboard in second place (13/30), and canvas in third place (12/30). There is no similarity in the implemented strategies across the LMSs, but the use of reminders, liking, and social roles appears to differentiate classroom most significantly.

System credibility assesses the perceived credibility of the LMS from the surface, from the initial perception of the UI to the accuracy of the content. Classroom outperformed the others (27/30), followed by blackboard (14/30), and canvas (14/30). Strategies such as expertise and authority were particularly strong in classroom.

Social support attempts to motivate students by leveraging social influence and interaction with peers by comparing performances, competing, or offering public recognition. Classroom achieved the highest score in the category (26/35), followed by blackboard (18/35), and canvas (7/35). Notably, classroom implemented more diverse strategies such as cooperation, recognition, and social facilitation, which were minimally present in canvas. It is important to note that these results reflect perceived persuasiveness based on self-reported data and may be influenced by individual differences in familiarity or expectations.

Table 7. Persuasive strategy evaluation by platform (Means by category)

Strategy	Blackboard	Classroom	Canvas
Reduction	4	5	3
Tunneling	4	5	3
Tailoring and personalization	3	3	2
Self-monitoring	4	4	2
Simulation	1	2	1
Rehearsal	1	4	1
Mean	2.83	3.83	2
Prices	4	2	2
Rewards	1	2	1
Reminders or suggestions	2	5	2
Similarity	1	1	2
Liking	3	4	3
Social role	2	5	2
Mean	2.16	3.16	2
Trustworthiness	2	4	4
Expertise	2	5	3
Surface credibility	4	5	3
Real world feel	1	4	2
Authority	2	5	1
Verifiability	3	4	1
Mean	2.33	4.5	2.33
Social learning	1	4	1
Social comparison	4	4	1
Normative influence	4	3	1
Social facilitation	4	4	1
Cooperation	2	5	1
Competition	1	2	1
Recognition	2	4	1
Mean	2.57	3.71	1

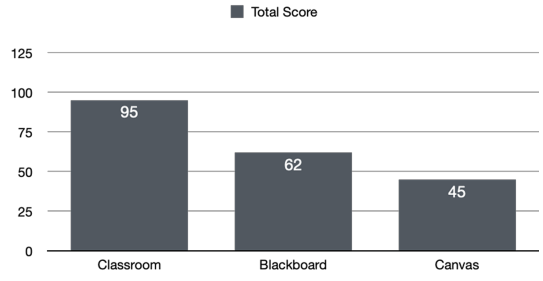


Figure 3. Persuasion evaluation total scores

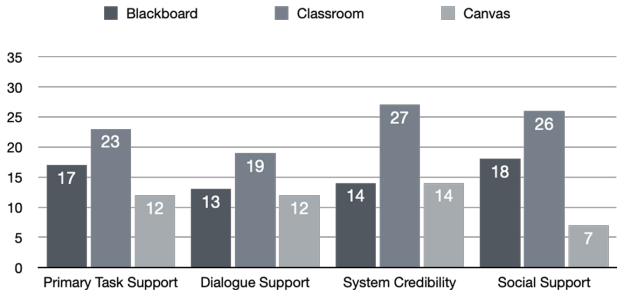


Figure 4. Persuasion evaluation scores by category

5. DISCUSSION

This study compared three widely used LMS from the perspectives of usability, accessibility, and persuasive design within the context of engineering education. Overall, canvas demonstrated the highest efficiency and effectiveness during assignment submission, whereas Google Classroom achieved the highest perceived persuasion scores across the four PSD categories. Blackboard presented intermediate performance but lower user satisfaction than the other evaluated platforms. Regarding accessibility, blackboard and canvas complied with the evaluated WCAG 2.1 criteria, whereas Google Classroom presented partial compliance in several accessibility-related aspects.

5.1. Usability implications

The usability findings partially agree with previous comparative studies on LMS evaluation. Gumasing *et al.* [9] reported no statistically significant differences in overall usability among blackboard, canvas, and Google Classroom, although Google Classroom obtained slightly higher overall SUS ratings. In contrast, the present study found that canvas achieved the highest perceived usability and the lowest task completion times. Although the Kruskal-Wallis analysis did not reveal statistically significant differences, the descriptive statistics consistently favored canvas regarding efficiency and effectiveness. Similarly, Algamdi *et al.* [10] reported that canvas outperformed blackboard in navigation and interface design while blackboard provided richer functionality. Our findings are consistent with this observation, as participants completed the assignment submission task more efficiently in canvas despite blackboard offering comparable functionality.

5.2. Persuasion implications

Unlike usability, the persuasion evaluation revealed a different pattern. Google Classroom obtained the highest scores across the four PSD dimensions, particularly in primary task support and system credibility. These findings suggest that students perceived Classroom as a platform that better guides users through academic activities while conveying higher credibility and trust.

These results align with previous work by Orji *et al.* [23] and Ahmad *et al.* [24] who reported that persuasive mechanisms embedded in educational systems contribute positively to learner engagement and participation. Likewise, Murillo-Muñoz *et al.* cite21 emphasized that persuasive educational systems can reinforce behaviors associated with learning persistence and motivation. Therefore, although classroom was not the fastest platform, its persuasive characteristics may positively influence students' long-term interaction with the LMS.

5.3. Accessibility implications

The accessibility evaluation demonstrated that none of the evaluated platforms fully addressed every aspect of inclusive interface design. Although blackboard and canvas complied with all manually evaluated criteria, Google Classroom presented partial compliance in several WCAG 2.1 requirements related to keyboard navigation, form labeling, and focus management. These issues may create additional barriers for students relying on assistive technologies or alternative interaction methods. Considering the increasing adoption of fully online engineering programs, accessibility should be considered a fundamental design requirement rather than an optional feature. Assignment submission is among the most frequent academic interactions, and even minor accessibility limitations may negatively affect students' learning experience.

5.4. Implications for engineering education

The findings of this study have practical implications for engineering education. Engineering students regularly interact with LMS platforms to submit laboratory reports, programming assignments, software projects, technical documentation, and collaborative activities. Consequently, efficient interfaces reduce the cognitive effort required to complete administrative tasks, allowing students to devote greater attention to problem solving and technical learning activities.

At the same time, persuasive mechanisms that promote guidance, feedback, and social interaction may contribute to sustaining student engagement throughout demanding engineering curricula. Therefore, LMS selection in engineering education should not rely exclusively on usability metrics but should also consider persuasive and accessibility characteristics that influence students' overall learning experience.

5.5. Limitations

This study presents several limitations. First, the sample size was relatively small and consisted exclusively of engineering students from a single institution, limiting the generalizability of the findings to other academic disciplines. Second, the experimental evaluation focused on a single high-frequency academic task—assignment submission—which, although representative of everyday LMS use, does not encompass the complete functionality of these platforms. Third, accessibility was evaluated through a manual WCAG 2.1 inspection rather than automated testing or evaluations involving users of assistive technologies. Finally, the between-subjects design prevented direct within-participant comparisons across LMS platforms.

6. CONCLUSION

This study evaluated the usability, accessibility, and persuasive design of three widely used LMS platforms—blackboard, canvas, and Google Classroom—from the perspective of engineering students performing a critical academic task: assignment submission.

The results indicate that Canvas offers the highest task efficiency, yet this does not directly translate into greater user satisfaction or perceived persuasiveness. Google Classroom, while more variable in efficiency, demonstrated stronger implementation of persuasive strategies, particularly in promoting user guidance, system credibility, and social interaction—all of which are vital for fostering student engagement in engineering education. Blackboard exhibited a mixed performance, with moderate efficiency and lower satisfaction and persuasion scores.

None of the platforms achieved full accessibility compliance, underscoring the need for improvements in form labeling, focus order, and color contrast to support an inclusive learning environment for all students, including those with disabilities or diverse access needs.

The results suggest that effective LMS design should not prioritize usability, accessibility, or persuasion independently, but rather integrate these complementary dimensions to support efficient task completion, equitable access, sustained student engagement, and positive learning experiences. Consequently, the proposed multidimensional evaluation framework may assist researchers, developers, and educational institutions in designing and selecting LMS platforms that are not only usable but also inclusive and persuasive, particularly in engineering education.

Future studies should extend this work by including students from different academic disciplines, evaluating additional LMS functionalities such as online assessments, discussion forums, and collaborative activities, and incorporating automated accessibility tools together with evaluations involving assistive technologies. Longitudinal studies may also provide a better understanding of how usability, accessibility, and persuasive design influence student engagement and academic performance over extended periods of LMS use.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal Analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject Administration
Fu : **Fu**nding Acquisition

CONFLICT OF INTEREST STATEMENT

The author(s) did not report any potential competing interests.

ETHICAL APPROVAL

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research involved voluntary participation of engineering students who interacted with Learning Management System (LMS) interfaces to perform predefined tasks. No sensitive personal or health-related data were collected, and participants' anonymity was preserved. All participants provided informed consent prior to the study. According to institutional regulations, formal approval from the ethics committee was not required, as the study did not involve medical procedures, vulnerable populations, or the processing of identifiable personal information.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available at [Blind review]

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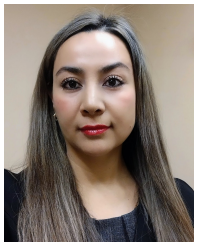
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