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A Contextual Digital Learning Model: Integrating CSCL and Project-Based Learning in E-Learning for CAD Education

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Abstract

This study aims to develop a Computer-Supported Collaborative Learning based instructional design through the integration of an e-learning platform in the Computer Aided Design (CAD) course at Universitas Negeri Padang, employing a Project-Based Learning approach and social constructivism. The study adopts the ADDIE development model, which consists of analysis, design, development, implementation, and evaluation stages. The results of expert validation, involving both content and media experts, indicate that the developed instructional materials are categorized as highly feasible. The implementation was conducted using a blended learning scheme and demonstrated significant improvements across multiple learning outcomes. Students' conceptual understanding increased, engagement improved, and learning satisfaction rose. In addition, students' learning motivation showed a consistent overall improvement. These findings suggest that the developed Computer-Supported Collaborative Learning-based instructional design is not only technically effective but also enhances collaborative interaction, fosters critical thinking skills, and prepares students to meet industry demands. This study contributes to the advancement of contextual digital learning models in engineering education and recommends the integration of learning analytics to support continuous evaluation and improvement.

INTRODUCTION

The rapid advancement of digital technology has significantly transformed the landscape of higher education, shifting learning paradigms toward more student-centered, collaborative, and technology-enhanced environments (Marshall et al., 2024). Contemporary education emphasizes not only cognitive development but also the integration of affective and psychomotor domains through meaningful and interactive learning experiences. In this context, digital learning environments are expected to facilitate active engagement, collaboration, and knowledge construction, aligning with the demands of 21st-century skills (Novalia et al., 2025).

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Within engineering education, particularly in Computer Aided Design courses, the integration of digital tools is essential. Computer Aided Design serves not only as a technical instrument but also as a cognitive tool that enables students to translate abstract ideas into precise visual and technical representations. However, recent studies indicate that students' proficiency in Computer Aided Design remains suboptimal, primarily due to limited understanding of software functionalities and insufficient practice in authentic contexts. This limitation often leads to inaccuracies in design outcomes and reduced readiness for industry demands (Koziar et al., 2025).

At the same time, the adoption of Learning Management Systems has provided new opportunities to support flexible and scalable learning. Despite their potential, Learning Management Systems platforms are frequently underutilized, functioning mainly as repositories for learning materials rather than as interactive environments that foster collaboration and higher-order thinking skills. Empirical evidence suggests that the lack of pedagogical integration in Learning Management Systems-based learning reduces student engagement and limits the effectiveness of digital learning environments (Abid et al., 2024).

To address these challenges, Computer-Supported Collaborative Learning has emerged as a promising approach that emphasizes social interaction and collaborative knowledge construction. Computer-Supported Collaborative Learning is grounded in social constructivist theory, which posits that learning occurs through active participation and interaction within a community. Recent research demonstrates that Computer-Supported Collaborative Learning environments can enhance student engagement, critical thinking, and collaborative skills when effectively integrated with digital technologies (Chan et al., 2024).

Furthermore, integrating Project-Based Learning into Computer-Supported Collaborative Learning environments offers a powerful pedagogical framework for bridging theory and practice. Project-Based Learning enables students to engage in authentic problem-solving activities, thereby fostering creativity, problem-solving skills, and industry-relevant competencies. Studies have shown that Project-Based Learning significantly improves students' learning outcomes and professional readiness, particularly in technology-driven disciplines (Abedi, 2024).

However, despite the growing body of research on Computer-Supported Collaborative Learning, Project-Based Learning, and Learning Management System-based learning, there remains a critical gap in their integrated application within Computer Aided Design learning in engineering education. Current studies predominantly examine Computer-Supported Collaborative Learning, Project-Based Learning, or Learning Management System in isolation, leaving a critical gap in developing a holistic instructional framework that integrates collaborative, project-based, and technology-enhanced learning specifically for Computer Aided Design education. This limitation highlights the need for a comprehensive instructional design that aligns technological affordances with pedagogical strategies and domain-specific content.

Therefore, this study proposes the development of a Computer-Supported Collaborative Learning-based instructional design integrated with an e-learning platform for Computer Aided Design courses, employing a Project-Based Learning approach. The novelty of this study lies in the synergistic integration of Computer-Supported Collaborative Learning, Project-Based Learning, and e-learning within a structured instructional design model (ADDIE), specifically tailored for engineering education. Unlike previous studies that emphasize either system efficiency or isolated pedagogical interventions, this research offers a comprehensive framework that integrates technology, pedagogy, and content in a unified learning environment.

This study contributes to the advancement of digital learning models in engineering education by providing an empirically validated instructional design that enhances student engagement, critical thinking, and collaborative learning outcomes. Additionally, it offers practical implications for educators in designing technology-enhanced learning environments and recommends the integration of learning analytics to support continuous improvement and data-driven decision-making in digital education.

METHODS

This study employed a developmental research design to develop and evaluate a Computer-Supported Collaborative Learning-based instructional model integrated with e-learning for Computer Aided Design courses. A mixed-methods approach was adopted, combining qualitative and quantitative data to support both the development process and product evaluation.

The participants included undergraduate students from the Building Engineering Education program at Universitas Negeri Padang who were enrolled in the Computer Aided Design course. The course instructor was involved as a practitioner-expert, while validation was conducted by two subject-matter experts and two instructional media experts. Participants were selected using purposive sampling, consisting of third- and fourth-semester students who had completed prerequisite courses in Engineering Drawing and Computer Applications.

The development process followed the ADDIE model, consisting of five phases: i) analysis of learning needs and existing practices; ii) design of a Computer-Supported Collaborative Learning–Project-Based Learning (PjBL) instructional framework; iii) development of web-based learning materials and activities integrated into the e-learning platform; iv) implementation in a blended learning environment; and v) evaluation through formative and summative assessment (Padilah et al., 2025; Siregar & Rhamayanti, 2025; Yahya et al., 2024; Yulianto, 2026; Yusuf et al., 2026).

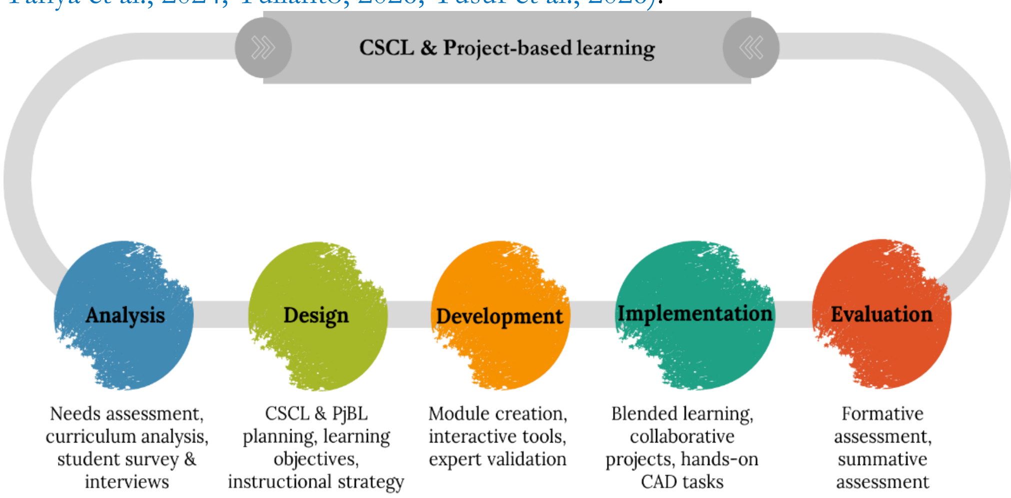

Fig 1. The development process followed the ADDIE model

Data were collected using validation sheets, questionnaires, observations, and learning outcome tests. Quantitative data were analyzed using descriptive statistics to determine feasibility and effectiveness, while qualitative data from expert feedback and observations were analyzed thematically to support iterative refinement of the instructional design.

Multiple data collection techniques were employed to ensure a comprehensive evaluation of the developed instructional design. Students' perceptions regarding learning needs and satisfaction were collected using structured questionnaires. In addition, structured interviews were conducted with course instructors to obtain in-depth insights into the feasibility, usability, and pedagogical relevance of the instructional materials (Aryasutha et al., 2025; Busral et al., 2025; El Said, 2017; Engkizar et al., 2017; Kaema & Ulwi, 2025; Maryanti & Kurniawan, 2018; Sandra et al., 2024; Qondias et al., 2016).

Learning activities were systematically observed to identify the level of student. engagement during both online and face-to-face sessions. To assess improvements in students' conceptual understanding, pre-test and post-test assessments were administered before and after the implementation of the instructional design. Furthermore, learning analytics data from the e-learning platform were analyzed to examine patterns of interaction, participation, and collaborative engagement in the digital learning environment (Kew & Tasir, 2022; Mikić et al., 2025).

Qualitative data were analyzed using a thematic analysis approach, which involves data familiarization, coding, theme development, and interpretation to generate meaningful insights (Braun & Clarke, 2021). Meanwhile, quantitative data were analyzed using descriptive statistics, including mean scores, percentages, and standard deviations, to evaluate the feasibility and effectiveness of the instructional product. To determine the magnitude of learning improvement, the normalized gain score (N-gain) was applied to compare pre-test and post-test results (Aziz et al., 2022).

The effectiveness of the developed instructional design was determined based on the following criteria: Expert validation scores reached a minimum of 80%, indicating a "highly feasible" category. Positive responses were obtained from at least 80% of both instructors and students. The average learning outcome score reached a minimum of 75, or the N-gain value was $\geq$ 0.3, indicating a moderate to high level of improvement. Student participation in online learning activities through the e-learning platform reached at least 75%.

RESULT AND DISCUSSION

This study resulted in the development of a web-based instructional design integrated with an e-learning platform for the Computer Aided Design course. The findings are structured based on the ADDIE development phases and focus on three key aspects: i) the feasibility of the instructional design as evaluated by experts, ii) its implementation in the learning process, and iii) user responses and student learning outcomes.

The developed instructional design underwent a rigorous validation process involving two subject-matter experts and two digital learning media experts. The validation covered several dimensions, including content accuracy, instructional design and content organization, language clarity, and the effectiveness of technology integration within the e-learning platform.

The results indicate a high level of feasibility. The average validation score from subject-matter experts reached 88%, reflecting that the instructional content is highly relevant, accurate, and aligned with the intended learning outcomes of the Computer Aided Design course. Meanwhile, the media experts assigned an average score of 85%, suggesting that the instructional design demonstrates strong usability in terms of navigation, user interface design, and the integration of multimedia elements within the e-learning environment.

These findings confirm that the developed instructional design meets the criteria of a "highly feasible" learning product, both from pedagogical and technological perspectives. The high validation scores also indicate that the integration of Computer-Supported Collaborative Learning and Project-Based Learning (PjBL) within the e-learning platform has been effectively operationalized into a structured and user-friendly learning environment.

In addition to quantitative validation results, qualitative feedback from experts provided important insights for refinement. The experts recommended the inclusion of more authentic, real-world case studies to strengthen the contextual relevance of learning materials. Furthermore, they emphasized the need to enhance collaborative components, particularly through structured discussion forums and group-based project tasks. These recommendations were systematically incorporated into the final revision of the instructional design, resulting in an improved version that better supports collaborative and experiential learning.

From a broader perspective, these findings are consistent with recent studies highlighting the importance of aligning instructional design with both pedagogical principles and technological affordances to ensure effective digital learning environments. The strong validation results suggest that the developed model not only meets quality standards but also has the potential to enhance collaborative engagement and higher-order thinking skills in engineering education contexts.

Implementation of the Instructional Design

The validated web-based instructional design was subsequently integrated into the e-learning platform and implemented over four sessions within a Computer Aided Design course cycle. The implementation was grounded in the principles of Computer-Supported Collaborative Learning, emphasizing structured interaction, shared knowledge construction, and collaborative problem-solving among students.

In each session, learning materials were delivered in digital formats, including textual explanations, video tutorials, and interactive design simulations. The learning process was organized through team-based project activities, where students worked collaboratively to complete design tasks using the e-learning platform. Computer-Supported Collaborative Learning features such as discussion forums, group assignments, and peer interaction tools were systematically utilized to facilitate communication, coordination, and co-construction of knowledge.

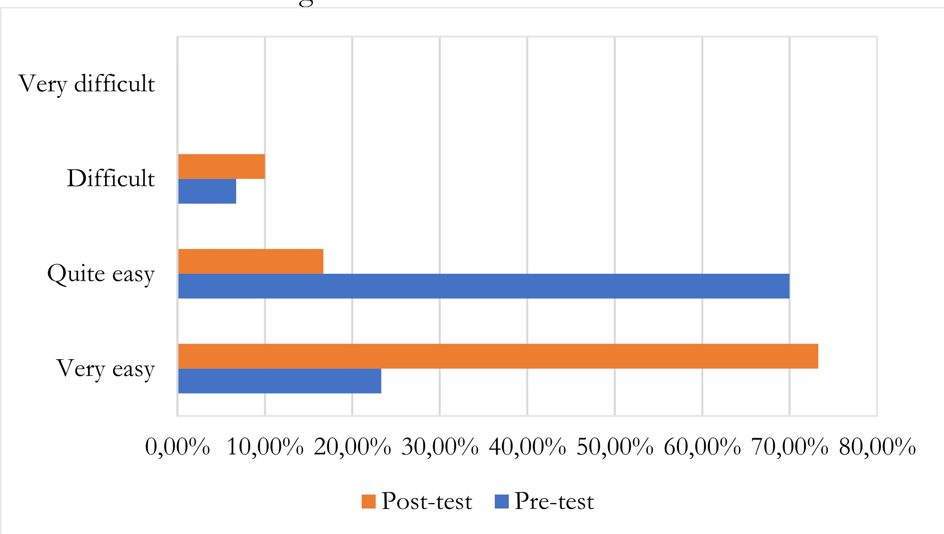

Fig 2. Ease of access to learning materials

Problem-solving activities were supported through thematic online discussion forums, allowing students to exchange ideas, provide feedback, and reflect on design solutions. Formative assessment was conducted through interactive quizzes and structured peer-review activities, enabling continuous monitoring of learning progress and collaborative evaluation.

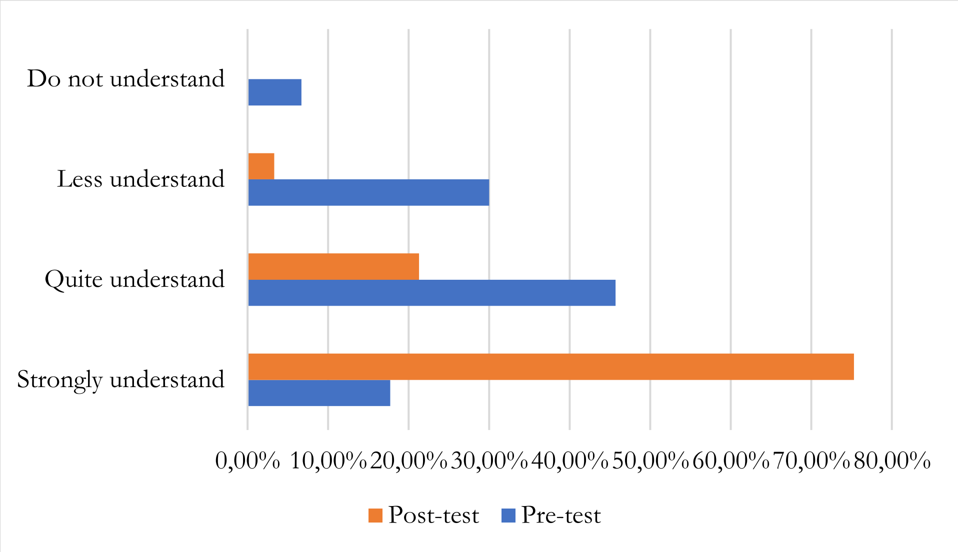

Fig 3. Understanding of the material

During the implementation, key e-learning features such as quizzes, assignments, announcements, and discussion forums were effectively utilized by the instructor to support both instructional delivery and collaborative learning processes. The level of student engagement indicates a strong adoption of the Computer-Supported Collaborative Learning environment. Participation in online discussion forums reached 75.3%, timely submission of group-based project assignments was achieved by 92% of students, and full participation (100%) was observed in interactive quizzes conducted during two evaluation sessions.

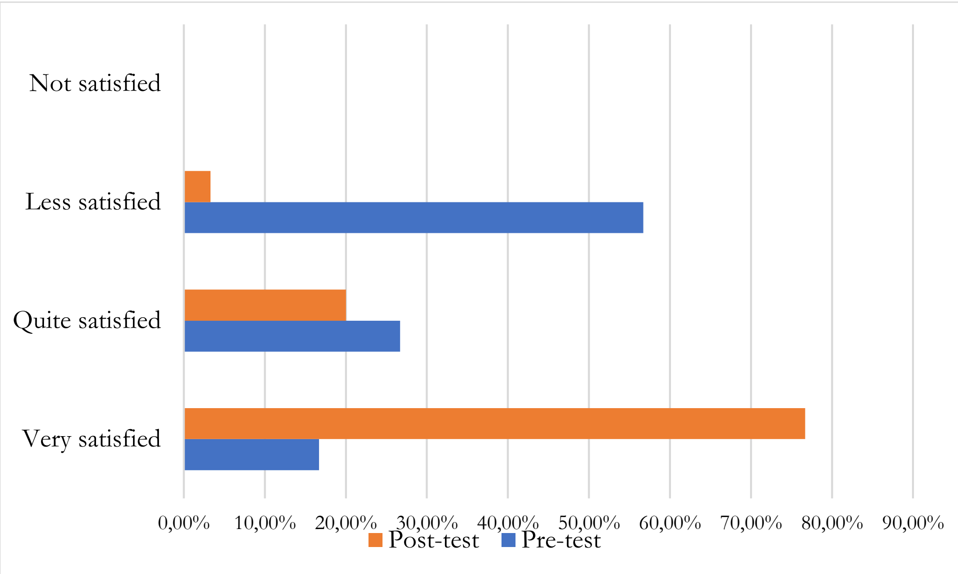

Fig 4. Satisfaction with learning method

Moreover, the intensity and quality of interaction between students and the instructor improved significantly. This was reflected in the frequency of online discussions, the depth of collaborative exchanges, and the consistency of feedback provided throughout the learning process. These findings suggest that the integration of Computer-Supported Collaborative Learning within the e-learning environment effectively promotes active engagement, collaborative learning, and continuous interaction, which are essential components of meaningful learning in engineering education.

User Responses (Students and Instructor)

Students' responses to the developed instructional design were collected a satisfaction questionnaire, focusing on their perceptions of learning effectiveness, flexibility, and collaborative experience within the Computer-Supported Collaborative Learning environment. The findings indicate a highly positive response from students.

Approximately 88% of students reported that the instructional design significantly enhanced their understanding of Computer Aided Design concepts, particularly through collaborative activities and shared problem-solving processes. Furthermore, 82% of students indicated that the integration of e-learning within a Computer-Supported Collaborative Learning framework provided greater flexibility and increased their learning motivation, as it enabled them to actively participate in both synchronous and asynchronous interactions.

In addition, 84% of students expressed that project-based tasks facilitated the integration of theoretical knowledge with practical design applications. This result highlights the effectiveness of combining Computer-Supported Collaborative Learning with Project-Based Learning, where students engage in collaborative knowledge construction and apply concepts in authentic design contexts. The presence of discussion forums and group-based activities further supported peer interaction, idea exchange, and reflective learning.

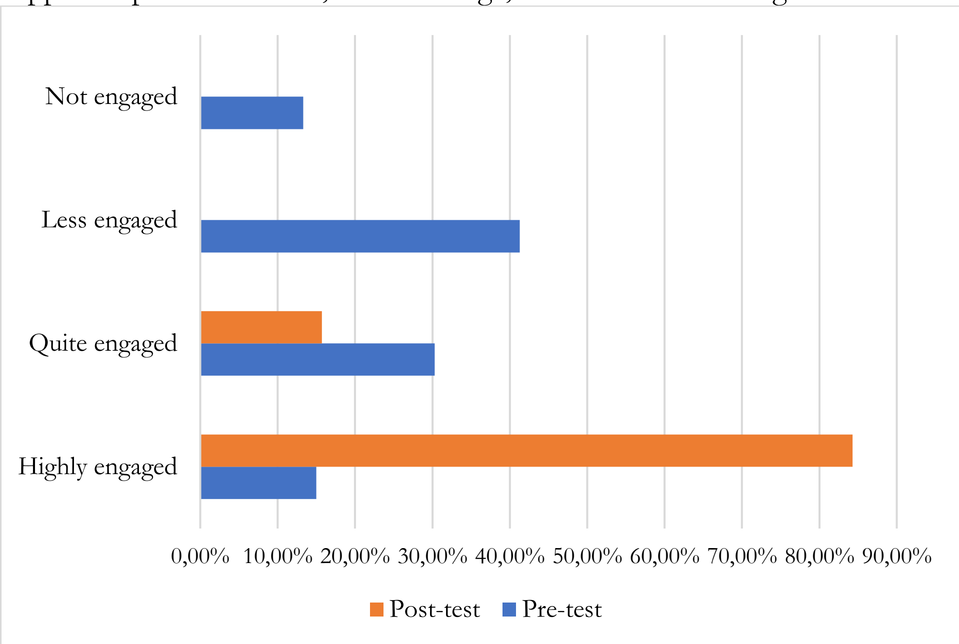

Fig 5. Engagement in learning

From the instructor's perspective, the instructional design was perceived as highly beneficial in terms of content management, learning facilitation, and assessment implementation. The e-learning platform enabled more structured and efficient organization of learning materials, assignments, and evaluation processes. Moreover, the instructor reported a noticeable increase in the quality and frequency of online interactions with students, particularly in facilitating collaborative discussions and providing timely feedback.

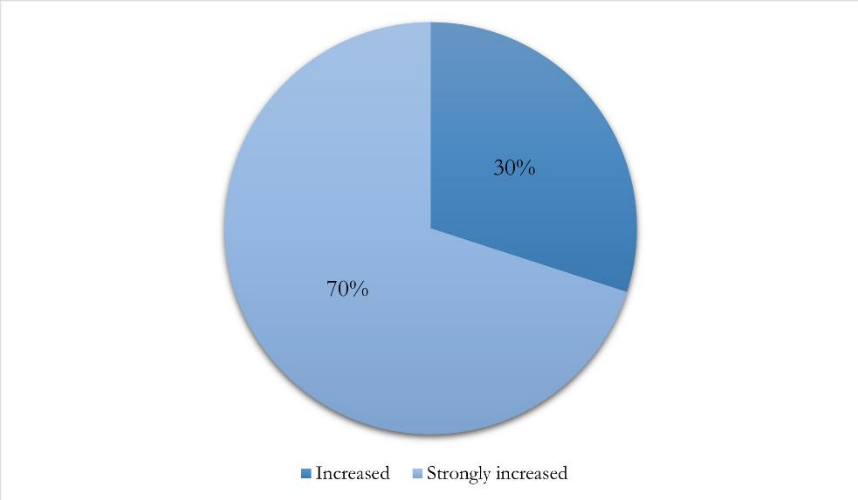

Fig 6. Leaning motivation

The use of Computer-Supported Collaborative Learning also allowed for more systematic and transparent assessment of student performance, as learning activities, participation, and contributions could be tracked through the e-learning system. Overall, both students and the instructor acknowledged that the developed instructional design fostered a more interactive, collaborative, and engaging learning environment, aligning with the core principles of Computer-Supported Collaborative Learning in enhancing meaningful learning experiences.

To examine the effectiveness of the developed instructional design, students' learning outcomes were analyzed using pre-test and post-test scores. The improvement in conceptual understanding was further measured the normalized gain score (N-gain) to determine the magnitude of learning improvement.

Table 1. Normalized gain score (N-gain)

Measurement	Score (%)	Description
Pre-test	31.5%	Initial level of understanding
Post-test	78.4%	Final level after implementation
N-gain score	0.68%	Moderate-to-high improvement

This result suggests that the integration of Computer-Supported Collaborative Learning with Project-Based Learning (PjBL) in a blended e-learning environment effectively enhances students' conceptual understanding in Computer Aided Design. The improvement can be attributed to several factors. First, the collaborative learning environment enabled students to actively construct knowledge through peer interaction and shared problem-solving. Second, the project-based approach facilitated the application of theoretical concepts into authentic design tasks, reinforcing deeper learning. Third, the use of interactive digital resources, such as simulations and video tutorials, supported self-paced and flexible learning.

Furthermore, the consistent increase in student engagement, participation, and motivation during the implementation phase aligns with the observed improvement in learning outcomes. These findings confirm that the developed instructional design not only meets feasibility criteria but also demonstrates strong effectiveness in improving student learning performance.

Improvement of Learning Outcomes

To evaluate the effectiveness of the developed instructional design, pre-test and post-test assessments were conducted involving 30 undergraduate students enrolled in the Computer Aided Design course. The results provide clear evidence of substantial improvement in students' learning outcomes after the implementation of the web-based, Computer-Supported Collaborative Learning-integrated instructional design.

The pre-test results indicated a significant gap in students' initial understanding and highlighted the urgent need for a more accessible and structured learning system. Students reported difficulties in accessing learning materials and demonstrated limited conceptual comprehension, which reflects the inadequacy of conventional instructional approaches. These findings underscore the importance of integrating a web-based learning environment to support flexible access and enhance learning effectiveness.

Following the implementation, the post-test results revealed a marked improvement not only in students' conceptual understanding but also in their learning satisfaction, engagement, and motivation. Students responded positively to the integration of instructional materials within the e-learning platform, indicating that the system facilitated easier access to resources anytime and anywhere.

The implementation process involved a series of systematically integrated activities, including the review and redesign of instructional plans, the development of course learning outcomes, the preparation of digital learning materials, the design of project-based tasks (jobsheets), the refinement of assessment instruments, and continuous monitoring and evaluation. These components were aligned within a Computer-Supported Collaborative Learning framework, enabling students to engage in collaborative, interactive, and technology-enhanced learning experiences.

Moreover, the integration of the instructional design into the e-learning platform contributed to the creation of a more modern, efficient, and industry-relevant learning environment. The approach supported not only independent learning but also collaborative knowledge construction, consistent with the principles of Computer-Supported Collaborative Learning. This aligns with the broader vision of higher education institutions to foster digital competence, active learning, and workforce readiness.

Overall, the findings demonstrate that the developed instructional design significantly improves learning outcomes and provides a meaningful learning experience by combining flexibility, interactivity, and collaboration within a technology-enhanced environment.

The implementation of Computer-Supported Collaborative Learning significantly contributes to the development of students' digital literacy skills. Through continuous engagement with the e-learning platform, students become more proficient in managing their learning time, accessing and utilizing multimedia resources, and participating in meaningful and productive online discussions. These activities not only enhance technical competencies but also foster critical digital skills required in contemporary learning environments (Falloon, 2020; Kalyani, 2024).

Furthermore, the integration of a social constructivist approach within Computer-Supported Collaborative Learning -based learning activities such as collaborative discussions, group-based projects, and individual reflections encourages students to actively construct knowledge both independently and collaboratively. This learning environment promotes deeper cognitive processing, as students engage in negotiation of meaning, peer feedback, and shared problem-solving processes.

These findings are consistent with recent research emphasizing that social interaction and collaborative engagement are fundamental to effective learning in digital environments (Lu & Churchill, 2014; Molinillo et al., 2018). While earlier foundational work highlighted the importance of social interaction in knowledge construction, contemporary studies further demonstrate that technology-mediated collaboration enhances not only understanding but also higher-order thinking skills and learner autonomy in online and blended learning contexts.

Overall, the integration of Computer-Supported Collaborative Learning within e-learning environments creates a dynamic learning ecosystem that supports digital literacy, collaborative competence, and meaningful knowledge construction, aligning with the demands of 21st-century education.

The findings of this study provide strong evidence that integrating Computer-Supported Collaborative Learning, Project-Based Learning (PjBL), and e-learning can significantly enhance learning effectiveness in engineering education, particularly in Computer Aided Design courses. The improvement in students' learning outcomes, engagement, and collaborative interaction is consistent with recent studies highlighting the benefits of technology-enhanced collaborative learning environments.

The significant N-gain score obtained in this study aligns with prior research indicating that Computer-Supported Collaborative Learning environments promote deeper understanding through social interaction and knowledge co-construction (Wibawa et al., 2025). The collaborative features embedded in the e-learning platform, such as discussion forums and group-based projects, enabled students to actively exchange ideas and refine their understanding, which is a key principle of social constructivism.

In addition, the integration of Project-Based Learning (PjBL) contributed to the improvement of students' ability to connect theoretical knowledge with real-world applications. This finding is in line with (Boey et al., 2023; Žerovnik & Nančovska Šerbec, 2021), who reported that project-based learning enhances problem-solving skills and professional readiness in technology-related disciplines. The authentic tasks provided in this study allowed students to engage in meaningful learning experiences that simulate real industry practices.

The positive responses from both students and the instructor further support the effectiveness of the developed instructional design. Consistent with (Vanslambrouck et al., 2018), the use of blended and flexible learning environments was found to increase student motivation and participation. Moreover, the integration of learning analytics through the e-learning platform enabled more structured monitoring of student progress, supporting data-driven instructional decisions (Sajja et al., 2025).

Despite these positive outcomes, several limitations should be acknowledged. The implementation was conducted within a limited number of sessions and participants, which may affect the generalizability of the findings. Future research is recommended to involve larger samples, longer implementation periods, and the integration of advanced learning analytics to further optimize collaborative learning processes.

Overall, this study contributes to the growing body of literature on digital learning in engineering education by providing an integrated instructional model that effectively combines Computer-Supported Collaborative Learning, PjBL, and e-learning. The findings highlight the importance of aligning technological tools with pedagogical strategies to create meaningful, collaborative, and industry-relevant learning experiences.

The results of this study demonstrate that the development of a web-based instructional design integrated into an e-learning platform significantly improves both the learning process and outcomes in the Computer Aided

Design course. These findings highlight that the integration of digital technology in engineering education is not merely about providing technological infrastructure, but more importantly about designing pedagogically sound learning environments that align with students' needs and industry demands.

The significant improvement in learning outcomes, as reflected in the N-gain score (0.68) and increased student participation in online activities, indicates that the integration of Computer-Supported Collaborative Learning and Project-Based Learning (PjBL) effectively creates meaningful learning experiences. This is consistent with contemporary perspectives on social constructivism, where learners actively construct knowledge through interaction, collaboration, and authentic problem-solving.

Learning Satisfaction and Motivation

The findings related to learning satisfaction (figure 3) reveal a substantial improvement after the implementation of the e-learning-based instructional design. The percentage of students categorized as "very satisfied" increased significantly from 16.7% (pre-test) to 76.7% (post-test), while the "less satisfied" category decreased sharply from 56.7% to 3.3%. This shift indicates that the learning experience became more engaging, interactive, and relevant when supported by a Computer-Supported Collaborative Learning-based digital environment.

From a motivational perspective, these results can be explained using Self-Determination Theory (SDT). According to Deci & Ryan, (2012), learning satisfaction is strongly influenced by the fulfillment of three basic psychological needs: autonomy, competence, and relatedness. The e-learning platform supports autonomy by allowing students to access materials flexibly, competence through structured tasks and feedback, and relatedness via collaborative discussions and group projects. Recent studies confirm that fulfilling these needs significantly enhances intrinsic motivation and engagement in digital learning environments (Aboobaker & K.H, 2022).

Furthermore, the increase in satisfaction is also aligned with the ARCS Motivation Model, which emphasizes attention, relevance, confidence, and satisfaction as key elements of effective instructional design. The integration of multimedia content, real-world projects, and interactive features in the e-learning platform successfully addressed these components, leading to higher levels of student satisfaction.

Accessibility and Learning Experience

The results related to accessibility (figure 1) show that the percentage of students who perceived learning materials as "very easy to access" increased significantly from 23.3% to 73.3%, indicating that the e-learning platform effectively enhances learning accessibility. This finding supports recent studies emphasizing that digital learning environments improve access to learning resources and enable flexible, self-paced learning (Ranieri et al., 2017).

Improved accessibility also contributes to a more positive learning experience, as students can engage with materials anytime and anywhere. This flexibility is a key characteristic of effective Computer-Supported Collaborative Learning environments, where learning is not constrained by time and space but supported through continuous digital interaction.

Conceptual Understanding and Engagement

A substantial improvement was also observed in students' conceptual understanding (figure 2), with the "very understand" category increasing from 17.7% to 75.3%. This indicates that the integration of Computer-Supported Collaborative Learning and multimedia learning resources effectively supports deeper cognitive processing. According to Mayer's Cognitive Theory of

Multimedia Learning in 2009, well-designed multimedia materials enhance understanding by facilitating dual-channel processing and active learning.

Similarly, student engagement (figure 4) increased dramatically, with the “highly engaged” category rising from 15% to 84.3%. This result confirms that Computer-Supported Collaborative Learning-based learning environments promote active participation and collaborative interaction. Previous studies have shown that engagement in online collaborative environments is strongly associated with improved academic performance and higher-order thinking skills (Liu & Zhang, 2022).

Learning Motivation and Digital Competence

The findings also reveal that 100% of students reported increased learning motivation, with 70% indicating improvement and 30% reporting significant improvement (figure 5). This demonstrates that the integration of Computer-Supported Collaborative Learning within e-learning environments not only enhances cognitive outcomes but also strengthens motivational aspects of learning.

Additionally, continuous interaction within the e-learning platform contributes to the development of students’ digital literacy and collaborative competencies, which are essential skills in the context of Industry 4.0 and modern engineering education (Schuster et al., 2017). Through activities such as online discussions, collaborative projects, and digital resource utilization, students develop both technical and social competencies required in professional contexts.

Overall Contribution

Overall, this study confirms that the integration of Computer-Supported Collaborative Learning within an e-learning platform is not merely a technological innovation, but a pedagogical transformation that enhances learning effectiveness, engagement, and student readiness for industry demands. The findings reinforce the importance of designing collaborative, interactive, and technology-enhanced learning environments that support meaningful learning experiences in higher education.

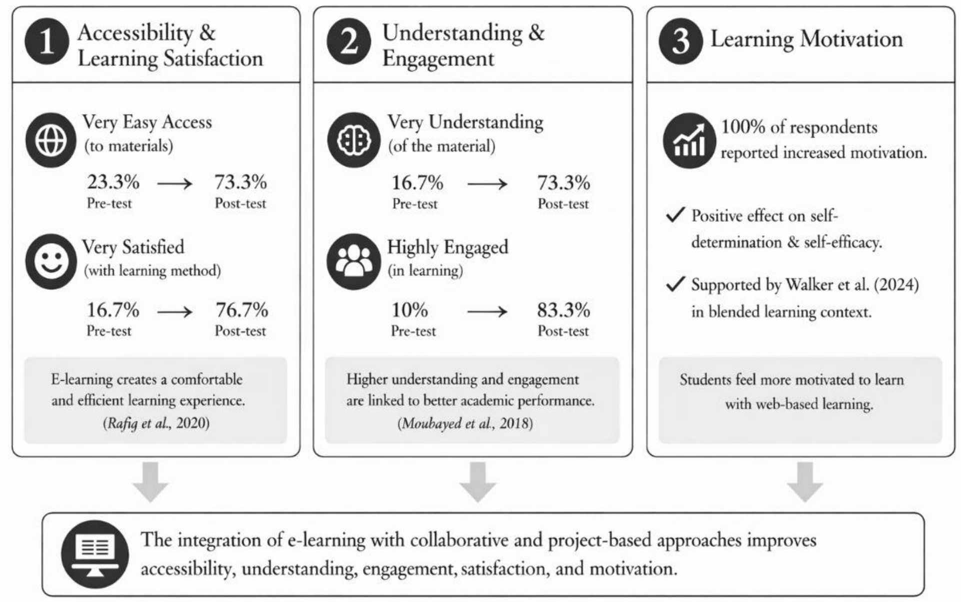

Fig 7. Overall Contribution

From a theoretical perspective, the effectiveness of interaction models involving content, instructors, and supporting systems is reinforced by recent findings. Zheng & Xiao, (2023) highlight that learner–content interaction and self-regulated learning play a crucial role in enhancing student satisfaction within digital learning environments. In addition, contemporary studies indicate that blended or hybrid learning approaches are more effective in promoting student engagement compared to purely traditional or fully online learning models.

Figure 2 presents a summary of the key findings derived from the analysis of students' pre-test and post-test data. The results clearly demonstrate significant improvements across three main dimensions: i) accessibility and learning satisfaction, ii) conceptual understanding and engagement, and iii) learning motivation.

In terms of accessibility and satisfaction, the proportion of students who perceived learning materials as "very easy to access" increased substantially from 23.3% to 73.3%, while those reporting being "very satisfied" rose from 16.7% to 76.7%. These findings suggest that the integration of e-learning platforms enhances both the usability and the overall learning experience. Improved accessibility allows students to engage with learning materials flexibly, which is a key characteristic of effective Computer-Supported Collaborative Learning environments (Jeong & Hmelo-Silver, 2016).

Regarding conceptual understanding and engagement, the percentage of students categorized as "highly understanding" increased from 16.7% to 73.3%, while active engagement rose significantly from 10% to 84.3%. This indicates that the Computer-Supported Collaborative Learning-based instructional design successfully fosters collaborative interaction, peer learning, and active participation. Such improvements are consistent with research demonstrating that collaborative digital learning environments enhance cognitive processing and academic performance (Sharma et al., 2024).

Furthermore, in terms of learning motivation, all respondents (100%) reported an increase after the implementation of the e-learning-based instructional design. This finding confirms that technology-enhanced collaborative learning environments can strengthen students' intrinsic motivation, self-efficacy, and learning autonomy. Recent studies emphasize that motivation in digital learning contexts is closely linked to students' perceptions of control, competence, and meaningful engagement (Hidayat-Ur-Rehman, 2024).

Overall, these findings confirm that the integration of e-learning with a Computer-Supported Collaborative Learning and social constructivist approach provides a more effective, efficient, and motivating learning experience. The combination of collaborative interaction, flexible access, and project-based activities enables students to actively construct knowledge, thereby improving both learning outcomes and overall learning quality in engineering education contexts.

CONCLUSION

This study concludes that the development of a web-based instructional design integrated with an e-learning platform has successfully achieved its primary objective, namely to create an interactive, adaptive, and contextual learning ecosystem in the Computer Aided Design course. The developed instructional design was found to be highly feasible in terms of both content and technical aspects, and demonstrated effectiveness in improving students' conceptual understanding, active engagement, learning satisfaction, and overall learning outcomes. The integration of Computer-Supported Collaborative Learning and Project-Based Learning within the instructional design significantly enhanced student participation, strengthened the connection between theoretical knowledge and practical application, and fostered collaborative and critical thinking skills. This approach also promoted meaningful learning experiences through social interaction, authentic problem-solving, and effective use of digital technologies.

Overall, the findings confirm that the pedagogically grounded integration of digital technology through social constructivism, Computer-Supported Collaborative Learning, and Project-Based Learning can substantially improve the quality of Computer Aided Design learning. These results provide important implications for engineering education, particularly in addressing the demands of 21st-century learning and the evolving needs of industry.

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