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PAPER

Improving Student Engagement and Success in Computer Programming Courses through Social Learning in Online Environments

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ABSTRACT

This paper addresses the necessity to enhance the effectiveness of online learning (OL) environments by examining the influence of social interactions on learner motivation, engagement, and success, specifically focusing on online computer science education (CSE). Acknowledging the limitations of peer-to-peer and learner-to-teacher interactions on online platforms, this paper delves into the potential of social learning (SL) organized through learner groups, communities, or networks to significantly enrich the learning experience. To test the hypothesis that SL positively impacts student outcomes, an experiment was conducted with 49 engineering students divided into two groups. The first group undertook an object-oriented programming course in C++ using the Moodle platform, while the second group, in addition to the online course, participated in asynchronous group activities through forums and synchronous interactions via chat. The results reveal a notable positive impact of SL on student outcomes, with participants in the second group reporting higher satisfaction levels and achieving superior results compared to those in the first group. The findings underscore the significance of integrating social interaction into OL environments, with potential implications for enhancing the overall quality of education and student performance in society.

KEYWORDS

computer science education (CSE), learning outcomes (LO), online learning (OL), social learning (SL), and student engagement (SE)

1 INTRODUCTION

Social learning theory (SLT) [1], [2] is increasingly recognized as a crucial element in positively changing learner behavior and improving the learning experience. According to Bandura's seminal work in 1977 [3], SL is the process by which individuals acquire new information, skills, attitudes, and behaviors through observation, imitation, and interaction with others in a social context. This phenomenon plays an

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essential role in human development, significantly determining people's behavior and beliefs. However, a problem arises in the context of e-learning, where there is often a lack of interactivity with e-learning platforms. This contributes to a high drop-out rate, which translates into lower motivation and overall student satisfaction.

It is useful to think of learning and teaching as "socially instrumented activities" [4], taking place in institutions with goals and values or in informal contexts. All three terms—"social," "instrumented," and "activity"—are important. "Activity" because it involves action (and listening is an activity); "social" because we learn with others, not alone, and with the help of people acting as tutors, teachers, or peers; "instrumented" because simple oral instruction is usually not enough, and we often use technology, including books, textbooks, notebooks, blackboards, whiteboards, computers, and other devices.

Figure 1 illustrates a model showcasing the educational opportunities provided by digital technology, conceptualized as "affordances," enabling new learning and assessment possibilities and experiences.

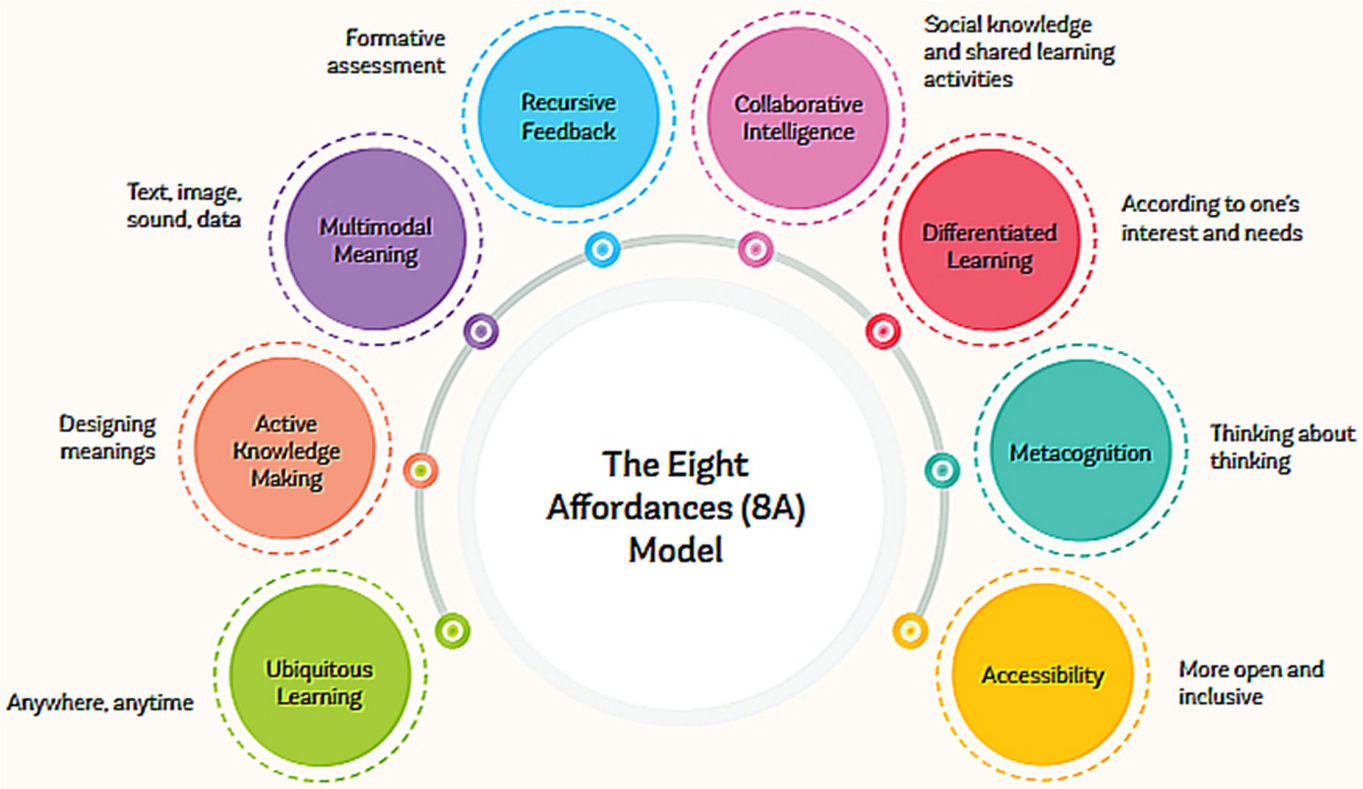

Fig. 1. Framework for exploring the educational potential of digital educational resources [4]

Traditionally focused on individual memory, education now recognizes the social aspect of knowledge and learning. Collaborative intelligence, rooted in social interaction, emphasizes working with peers, providing feedback, and participating in collaborative activities. Digital environments, such as online social networks, facilitate the creation of collaborative knowledge networks, enabling learners and teachers to form diverse collaborations and authentically share knowledge. This development fosters the emergence of dynamic learning communities and offers the possibility of collectively building unique pathways to achieve educational goals [4].

The aim of this study is to investigate whether implementing a SL approach can improve student performance in a computer science course on object programming

in the C++ language. In particular, we rely on the following two assumptions: The null hypothesis, or H0, postulates that the implementation of a SL approach does not significantly improve student performance, while the alternative hypothesis, or H1, suggests that it does lead to a significant improvement. To reject one of the two hypotheses, an experiment was conducted with a class of 49 engineering students, divided into two groups. We used a two-group experimental design employing a comparative methodology, using a control group (Group 1) and an experimental group (Group 2) to evaluate the effectiveness of two pedagogical approaches within the Moodle OL platform. Before applying the procedure, we ensured that the two groups were homogeneous and equivalent. The students were assigned to groups according to their skill level, thus ensuring equivalence within each group. Demographic characteristics such as age and gender were taken into account during the assignment process to reinforce homogeneity. The first group followed a course on Moodle, then took self-assessment quizzes and a final test. In contrast, the second group of students had to participate in interactive group activities before taking quizzes and the final test, which is a series of multiple-choice questions on the subject, designed to assess knowledge and understanding of object-oriented programming concepts. The role of the teacher remains essential in guiding and supporting learners. The results of the study indicate that SL does indeed have a positive impact on students' academic performance. Notably, participants in the second group expressed significantly higher levels of appreciation and satisfaction than their counterparts in the first group. These results underline the importance of social interactions in OL environments, which can significantly enhance students' learning experiences and, consequently, their academic results. These results underline the need for educators and instructional designers to consider the principles of SL theory when designing and implementing an online course in order to achieve a more engaging and higher-quality educational experience.

The remainder of this paper is organized as follows: Section 2 describes the state of the art. Section 3 explains our proposed solution architecture and experimental design. The main results are presented and discussed in Section 4. Section 5 explains the limitations of our contribution. Section 6 is reserved for conclusions and perspectives.

2 RELATED WORK

Aljarallah et al. [5] focus on the social pillars of sustainability in the context of e-learning to address a study gap. While previous studies have primarily concentrated on technical and economic dimensions, this study emphasizes social aspects by integrating four key social pillars: social capital, social infrastructure, social justice and equity, and engaged governance. By analyzing Twitter data from the Gulf Cooperation Council (GCC) region during the COVID-19 pandemic, the study examines 11 social factors influencing the sustainability of e-learning. Engaged governance is identified as a primary concern (40.4%), followed by social infrastructure (25.8%), social justice and equity (19.6%), and social capital (14.2%). The proposed study model establishes a new framework for comprehending the social sustainability of e-learning and provides valuable insights for practitioners, developers, and policymakers to enhance the implementation of e-learning at the national level through legislative, organizational, educational, cultural, and social interventions. This study underscores the significance of the social dimension, particularly in education, and emphasizes its essential consideration across all fields.

In [6], the authors examined the use of a YouTube channel for asynchronous teaching in various learning environments. The results underscore the importance of social media in supporting learning processes.

Another study [7] examined the impact of social media platforms (Facebook, Twitter, and Instagram) on student engagement, knowledge acquisition, and academic performance in the context of distance learning. A survey of 400 students at the National Open University of Nigeria (NOUN) was conducted via an online platform to gather data on the frequency and types of social media platforms used by distance learners, as well as their perceptions of the effectiveness of these platforms for collaborative learning. The results showed the potential of platforms such as Facebook, Twitter, and Instagram to increase SE and facilitate knowledge acquisition. The study highlighted the potential for educators to create online communities or groups where students can participate in discussions, resource sharing, and collaborative projects. The study recommends that educators and distance learning institutions consider the strengths of different social media platforms when selecting tools for collaborative learning among distance learners. In addition, it highlights the importance of using social media platforms to promote collaboration and interaction and thus enhance the distance learning experience.

A fourth study provides an empirical examination of the effects of social media on various aspects of SL, such as knowledge acquisition, collaboration, information sharing, and community participation. The results offer insights into the pros and cons of utilizing social media platforms as effective SL tools. [8], [9].

The study of collaborative learning has evolved from a focus on the individual to a group-centered analysis. Early studies sought optimal conditions for collaboration, encountering challenges in establishing causal connections. Recent changes emphasize a process-oriented approach, requiring new tools. Focusing on specific categories of interaction and understanding negotiation mechanisms are crucial for effective models of collaborative learning. Verbal interactions, while promising, require in-depth exploration for computational models. This study [10] encourages psychologists and machine learning researchers to collaborate to build comprehensive models that integrate individual learning and verbal interactions for joint problem solving.

Another study [11] evaluates the effects of incorporating project-based learning with Multisim software on the outcomes of the audio-video system installation subject, showing a notable enhancement post-intervention.

Asbendri et al. [12] investigated the impact of using Tinkercad-assisted learning media on 11th-grade Electronics Engineering students' learning outcomes (LO). The study revealed an 11.5% improvement in the experimental group compared to traditional learning methods. Tinkercad significantly enhanced LO, indicating its potential integration into the curriculum to enhance the quality of education.

Lei Shi et al. [13] discuss the implementation of profiles in Topolor 2.0, an adaptive and personalized OL environment. Learners demonstrated strong acceptance of profile features in a case study, despite the limited number of participants. The results emphasize technical and pedagogical considerations, along with suggested future study directions. The primary limitation of the study is the small number of participants, but the publicly available Topolor 2.0 anticipates a larger cohort of users for expanded evaluation and improvement opportunities.

[14] investigates the impact of virtual social networks on the social skills of young people. The study, based on a survey of 107 students from a pedagogical university in Ukraine, reveals that a significant number of students use these networks regularly (51.4% browse 2–4 times daily). The primary purposes for students

using these networks are communication with classmates (80.4%) and friends and family (78.5%).

Agariadne et al. [15] aimed to design and test the effectiveness of the "E-LabSheet Project," a mobile-friendly learning supplement for computer network practicum. The study evaluated the validity, practicality, and effectiveness of the project, demonstrating improved LO in classes that used the supplement.

[16] examines the use of social media as a learning resource. The study's conclusion indicates that social media should be utilized appropriately and supplemented with guidance from teachers to help students achieve their learning goals optimally.

3 MATERIALS AND METHODS

The experiment utilized a comparative methodology to assess the effectiveness of two distinct pedagogical approaches within the Moodle e-learning platform, as illustrated in Figure 2. The study included two groups of engineering students: Group 1, identified as the control group, and Group 2, the experimental group, consisting of 25 and 24 students, respectively, as detailed in Table 1. Both groups had access to the same C++ programming course content. However, Group 1 followed a traditional Moodle-based course format, where students primarily worked independently on assignments and tasks. In contrast, Group 2 took part in the same C++ programming course, but with a deliberate emphasis on collaborative and SL activities. The instructor in our experiment played a crucial role in guiding discussions, offering timely feedback, and explaining concepts when necessary. Communication with students not only ensured the smooth running of collaborative activities but also enhanced the learning experience.

According to the conceptual framework proposed by Roschelle and Teasley [17], collaboration entails the mutual engagement of participants in a coordinated effort to solve problems collectively. Conversely, cooperation involves the division of labor among participants, with each individual responsible for specific aspects of problem-solving tasks. By integrating these concepts into the experimental design, the study aimed to evaluate the impact of these contrasting teaching methodologies on student outcomes, focusing on the role of SL in programming education.

In our experiment, we consciously focused on the eight affordances to explore the pedagogical possibilities of digital educational resources. These affordances served as a conceptual framework to design and structure our approach to SL in the online computer science course [18]. Firstly, accessibility was prioritized to ensure that educational resources were easily accessible to all learners, thereby fostering an inclusive environment. Differentiated learning was integrated by designing varied activities that allowed learners to choose learning routes suited to their individual needs. The collaborative learning dimension was implemented through asynchronous group activities on forums and synchronous exchanges in chat, thus promoting interaction between peers and with teachers. Recursive feedback has been integrated to provide learners with ongoing feedback on their performance, driving constant improvement. Multimodal meaning has been taken into account by offering varied resources, such as texts and discussions, to meet different learning preferences. Active knowledge-making was encouraged by placing learners at the center of the learning process and encouraging them to actively construct their own understanding of the content. Finally, ubiquitous learning has been facilitated by allowing learners to access educational resources flexibly, i.e., anytime, anywhere.

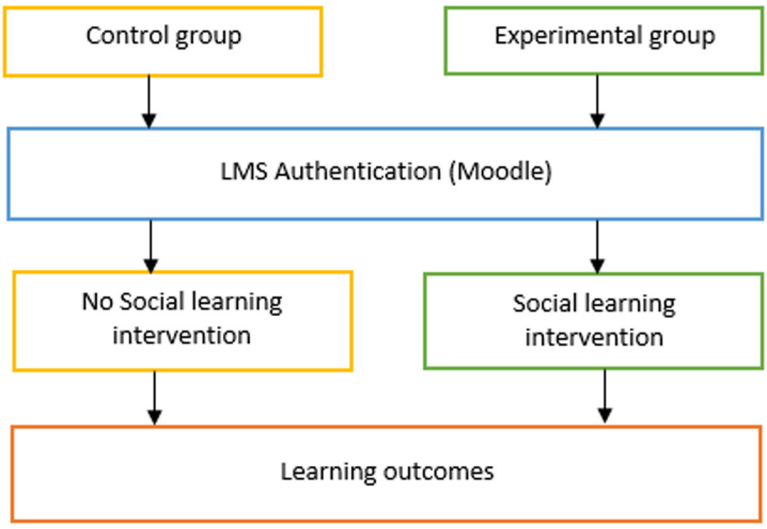

Fig. 2. Research design

Table 1. Participant demographics

	Control	%	Experimental	%
Female	6	24	6	25
Male	19	76	18	75
Total	25	100	24	100
Age				
• 18–20	5	20	5	21
• 21–24	20	80	19	79
• 22–25	0	0	0	0
University				
• 1st year of engineering	25	100	24	100

Using these eight affordances as a guide highlights the importance of considering these aspects in the design of OL environments. It emphasizes how a strategic approach can help create enriching and effective educational experiences.

The study aimed to elucidate how promoting collaborative interactions and SL in the virtual classroom environment could enhance students' understanding of programming concepts and improve overall LO. By comparing the performance and experiences of students in the control and experimental groups, the study aimed to provide empirical evidence of the effectiveness of integrating elements of SL into programming instruction.

Moodle was chosen as the e-learning platform for this experiment because of its accessibility, versatility, and collaborative features. As an open-source solution, Moodle offers a user-friendly interface and comprehensive course management tools, facilitating the seamless implementation of collaborative learning activities. Its robust functionality enables teachers to track student progress, administer online assessments, and customize course content, making it an ideal choice for evaluating the effectiveness of various teaching methodologies. Particularly in the context of teaching object-oriented programming, Moodle's adaptability enables the integration of SL elements, promoting interaction and knowledge sharing between

students. By taking advantage of Moodle's collaborative features, educators can create dynamic learning environments that cater to diverse learning styles and promote active engagement, enhancing the overall student learning experience. Moodle, therefore, appears to be a well-suited platform for evaluating the impact of SL in the context of teaching object-oriented programming.

3.1 Background and participants

The experiment was conducted in an educational setting, focusing on engineering students aged between 20 and 24, selected for their direct relevance to the study subject. This age group typically comprises individuals in the midst of their higher education journey, where gaining proficiency in programming languages such as C++ is crucial for their future engineering careers. Selecting this demographic group guaranteed that the study results would directly influence strategies and interventions customized to the requirements and experiences of this specific cohort.

Groups 1 and 2, consisting of 24% women and 76% men and 25% women and 75% men, respectively, were enrolled in the same C++ programming course delivered via the Moodle platform. This equal gender distribution between the two groups was intended to minimize potential confounding variables related to gender differences in learning preferences and experiences. It also guaranteed that any disparities in outcomes could be primarily attributed to the interventions implemented rather than to demographic differences.

The experiment took place in an OL environment enhanced by occasional face-to-face explanation sessions, aligning with the current trend towards digital education methods. This hybrid approach acknowledges the advantages of online platforms for flexibility and accessibility while also acknowledging the importance of synchronous interactions for clarification, discussion, and interpersonal engagement. By aligning with modern educational practices, the experiment not only leveraged cutting-edge technology but also remained sensitive to the diverse learning needs and preferences of today's students.

3.2 Social presence

Social learning, which encompasses various forms of interaction, plays a central role in enriching the educational experience. It involves the exchange of knowledge, ideas, and experiences between learners, fostering a sense of community. Social presence in online education can take the form of groups, forums, or collaborative activities, offering students the opportunity to participate in meaningful discussions and collaborative learning. In this study, we explore the impact of social interaction on the effectiveness of OL. We also highlight the central role of the teacher in guiding discussions, providing feedback, and facilitating a supportive learning environment.

In our experiment, we leveraged social presence by integrating synchronous and asynchronous interactions. Chat sessions facilitated real-time communication, enabling students to engage in spontaneous conversations, seek quick clarifications, and build camaraderie. The forums, on the other hand, provided a structured platform for more detailed discussions, sharing information, and collaborating on problem-solving. These casual interactions were designed to foster a supportive social atmosphere, motivating students to actively engage in their learning process.

- **Chat interactions:** The chat interactions served as dynamic spaces for real-time communication. Students utilized the chats for quick questions, discussions, and peer support. The informal nature of the chat sessions facilitated spontaneous conversations, enabling students to share ideas, seek assistance, and cultivate a sense of community. These interactions added a social dimension to the learning process, fostering connections beyond the formal structure of the course.
- **Collaborative forum:** The forums, as part of our SL strategy, provided a more structured environment for discussions. Students participated in asynchronous discussions, sharing ideas, resources, and problem-solving strategies. The forums encouraged active participation, allowing learners to reflect on course content, ask questions, and receive diverse perspectives. This structured approach to SL aimed to create a supportive online community, enhancing the overall learning experience for participants.

These social components were designed to address the limitations observed in traditional OL, promoting a more interactive and engaging educational environment. Through these interventions, we aimed to showcase the positive impact of SL on student satisfaction, engagement, and overall success in computer science education.

3.3 Details of the experimental procedure

In this study, the participants enrolled in a hybrid course on C++ object-oriented programming, which included face-to-face lectures and either face-to-face or online tutorials on the Moodle platform, depending on the group. The course spanned eight weeks and encompassed multiple chapters. After completing each chapter, participants took a self-assessment quiz to assess their comprehension. This approach allowed students to track their advancement and pinpoint areas in need of enhancement.

Once all the chapters had been completed, the control group (see Figure 3) and the experimental group (see Figure 4) took a final test. However, there is a crucial distinction between the two groups. The control group followed the traditional Moodle course structure, while the experimental group benefited from additional SL elements. The experimental group participated in asynchronous discussions through forums and engaged in real-time communications via chat sessions. These social elements were designed to enhance collaborative learning and foster a sense of community among the participants.

After the final test, students in both groups received a motivational questionnaire to gather information about their learning experience.

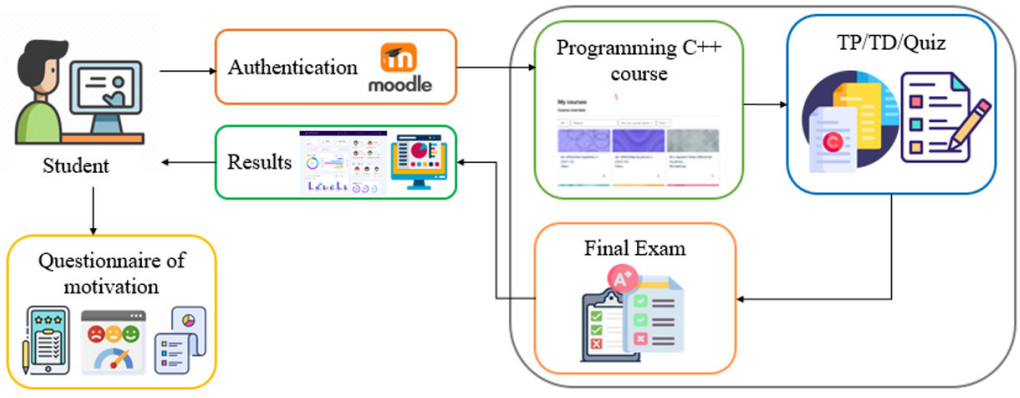

Fig. 3. Experimental procedure for the control group (Group 1)

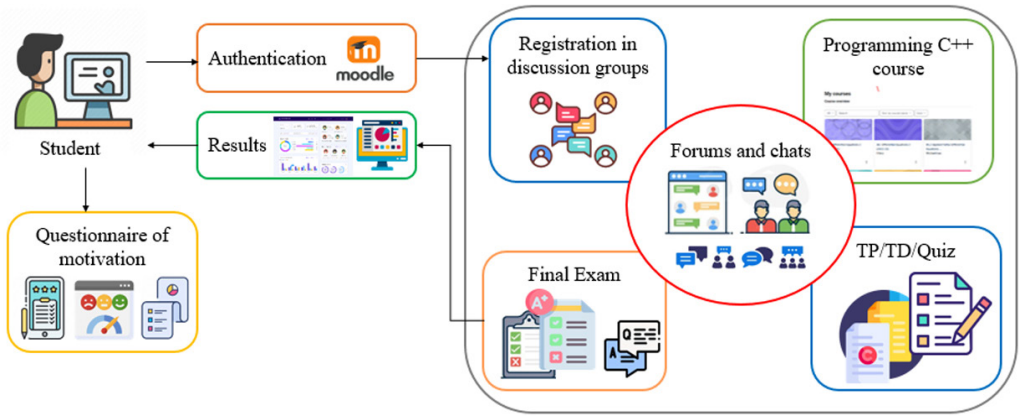

Fig. 4. Experimental procedure for the experimental group (Group 2)

4 MAIN RESULTS AND DISCUSSION

This section presents a comprehensive analysis of the experiment's results, synthesizing quantitative and qualitative data to assess the influence of SL on engineering students' performance. The data have been rigorously analyzed using specialized algorithms and methodologies to ensure a thorough examination and interpretation.

Quantitative metrics, such as final test scores and statistical measures like means, medians, and standard deviations, were meticulously examined to discern patterns and trends between experimental and control groups. These quantitative analyses provided a basis for evaluating the effectiveness of SL interventions.

Complementing the quantitative results, qualitative data from student comments, observations, and interactions was also carefully examined. Qualitative data offers nuanced perspectives on the learning experience, highlighting subjective aspects of student engagement, understanding, and satisfaction.

By integrating quantitative and qualitative approaches, a comprehensive understanding of the impact of SL on engineering students' performance emerges. This comprehensive analysis transcends simple statistical comparisons, delving deeper into the underlying mechanisms and dynamics at play in the learning environment. This multi-faceted evaluation approach strengthens the validity and reliability of the study results, offering valuable contributions to the field of educational study and informing future teaching practices.

4.1 Quantitative results

The quantitative results from the final test indicate a significant disparity between the experimental and control groups, highlighting the impact of incorporating both asynchronous (forums) and synchronous (chats) social activities on LO. In the experimental group, where these SL components were integrated, students demonstrated significantly higher scores compared to their counterparts in the control group. This finding emphasizes the importance of social interaction in educational settings and suggests that fostering collaborative learning environments can result in tangible academic benefits.

Examining the comparative data presented in Table 2 further illuminates the difference in performance between the two groups. On average, Group 2 exhibits a substantially higher score of 17.67 compared to the control group's average of

13.56, indicating a notable improvement in academic achievement. This trend is reinforced by the median scores, where Group 2's median score of 18 surpasses Group 1's median of 13. Additionally, the lower standard deviation observed in Group 2 (1.11) compared to Group 1 (1.88) suggests that the former group displays greater consistency in individual performance, further bolstering the argument for the efficacy of the interventions applied.

The statistical significance of these findings underscores the potential effectiveness of the specific methods or interventions employed in Group 2, which likely contributed to the overall enhanced performance observed. By integrating both asynchronous and synchronous social activities into the learning process, students were provided with opportunities for peer interaction, knowledge exchange, and collaborative problem-solving, all of which are known to promote deeper understanding and retention of course material.

Table 2. Comparison of the control and experimental group's final tests

	Control n = 25 Group 1	Experimental n = 24 Group 2
Average	13.56	17.67
Median	13.00	18.00
Standard deviation	1.88	1.11

Moreover, analyzing interactions within the chat platform provides valuable insights into SE levels. The average number of messages per student (15.82) indicates active participation in the virtual classroom environment. Although there is some variability in the number of messages sent by individual students, the overall distribution remains relatively balanced, with most students actively contributing. This indicates that the SL activities promoted meaningful engagement and interaction among students, fostering a sense of community and collective learning.

The quantitative results and accompanying analysis provide compelling evidence of the positive impact of integrating SL components into educational interventions. By utilizing both asynchronous and synchronous social activities, educators can establish dynamic learning environments that foster collaboration, critical thinking, and ultimately, enhanced academic performance. These findings highlight the significance of social interaction as a fundamental element of effective pedagogy, with implications for instructional design and classroom practice.

4.2 Qualitative results

Regarding the qualitative results, an analysis of the forum topics made it possible to identify the most popular discussion themes among the students. These discussions were primarily focused on specific parts of the course, providing insight into the topics that generate the most interest and participation in a SL context.

Figure 5 illustrates the quantitative results and analysis of forum topics, revealing a discrepancy in the treatment of themes. Some topics garner more interest than others within the Experimental Group. The high frequency of discussions on the topic (13) suggests that students pay particular attention to this concept, possibly due to

its complexity in the C++ programming language or its significance in the course. Similarly, the frequent discussions on (7) and (7) indicate a notable focus on specific programming language concepts. Conversely, topics such as (3) and (5) appear to be less prevalent in discussions. This variation could be attributed to factors such as the perceived difficulty of concepts, their practical relevance, or their order in the curriculum. In conclusion, these results suggest that the frequency of forum discussions is influenced by the complexity, relevance, and potentially the instructional sequence of different course concepts. The quantitative results and analysis of forum topics underscore the diversity and depth of social interactions and subjects deliberated within the experimental group, affirming its positive impact on student engagement.

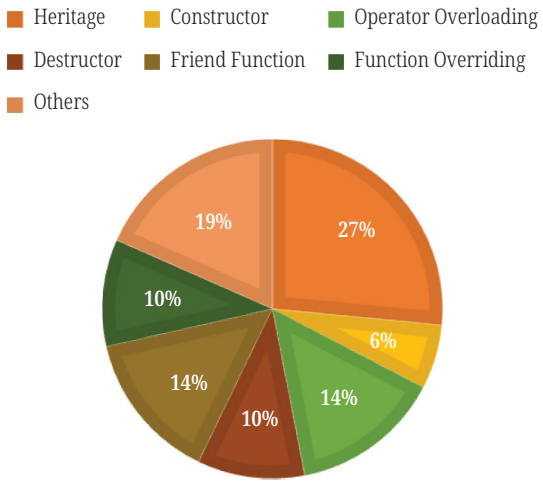

Fig. 5. The most frequent topics

The motivation questionnaires (see Tables 3 and 4), rated on a Likert scale of 1 to 5, also provided crucial information. In Group 2, individuals who benefited from social interactions showed higher motivation overall compared to Group 1. In Tables 1 and 2, response levels 1 and 2 of the Likert scale correspond to the column "not at all," level 3 corresponds to "moderately," and levels 4 and 5 correspond to "very much."

Table 3. Descriptive questionnaire results for the control group (Group 1)

	Not at All	Moderately	Very Much
Q1: How much did you enjoy the learning experience you took?	24%	44%	32%
Q2: How would you rate the quality of the learning content presented during this learning experience?	12%	48%	40%
Q3: How much do you think you learned from this learning experience?	16%	48%	36%
Q4: How do you evaluate the teaching method used in this group with online learning on Moodle?	24%	48%	28%
Q5: To what extent do you think this learning experience motivated you to learn?	20%	44%	36%
Q6: How would you recommend this learning experience to others?	4%	56%	32%

Table 4. Descriptive questionnaire results for the experimental group (Group 2)

	Not at All	Moderately	Very Much
Q1: How much did you enjoy the learning experience you took?	8.4%	8.3%	83.4%
Q2: How do you evaluate the exchanges with other students during this learning experience?	8.4%	12.5%	79.2%
Q3: How much do you think you learned from this learning experience?	8.4%	16.7%	75%
Q4: How do you evaluate the teaching method used with group learning?	8.4%	16.7%	75%
Q5: To what extent do you think this learning experience motivated you to learn?	8.4%	12.5%	79.2%
Q6: How would you recommend this learning experience to others?	8.4%	16.7%	75%

These quantitative and qualitative results converge to demonstrate the effectiveness of SL. Group 2, which actively engaged in social interactions and exhibited not only superior academic performance but also heightened levels of motivation. These outcomes underscore the pivotal role of incorporating social elements into OL environments, especially in the field of computer science education, to enhance student experiences and outcomes.

The questionnaire results further corroborate the positive impact of SL on student perceptions and experiences. Members of the experimental group overwhelmingly reported having a significantly more enriching learning experience, feeling that they acquired a deeper understanding of the subject matter, and expressing heightened levels of motivation compared to their counterparts in the control group. This alignment between student perceptions and objective performance metrics reinforces the notion that SL not only fosters academic achievement but also cultivates a more engaging and fulfilling learning environment.

We relied on SL theory, constructivism, and self-determination theory to guide the implementation of social interactions. These theories informed the design of collaborative activities, fostering knowledge construction, motivation, and engagement among students.

By recognizing the value of social interaction and collaboration in the educational process, educators can tailor instructional strategies to harness the benefits of SL. This approach ultimately fosters more meaningful learning experiences and facilitates better outcomes for computer science students.

5 LIMITATIONS

Our study has some limitations that should be highlighted. Firstly, our contribution is based on the integration of only two types of SL, namely asynchronous discussion forums and synchronous chat sessions. There are many different forms of SL, and our study covers only some of them. It would be useful to further diversify SL approaches to get a comprehensive picture of their impact on SE and success.

In addition, the number of students participating in our experiment was limited to two groups, totaling 49 students. While our analysis yielded significant results, conducting a study with a larger sample size could enhance the external validity of our findings. A more extensive study could facilitate a more comprehensive generalization of the impact of SL on academic performance.

Despite these constraints, our study provides important insights into the positive effect of SL on motivation. This is evidenced by the sharp increase in SE rates during social educational activities. Similarly, learner engagement, as illustrated by active participation in online discussions, was enhanced by regular social interactions. Additionally, student success was significantly improved by collaborative projects in which SL promoted a better understanding of concepts.

Future studies could expand on these findings by exploring various types of SL, such as discussion forums, group projects, or knowledge-sharing platforms. Expanding the sample would deepen and generalize understanding of the benefits of SL in OL environments, encompassing a variety of educational contexts and disciplines.

6 CONCLUSIONS

Once we had observed the deficits in social exchanges between peers and between learners and teachers in online training, we sought to demonstrate the potential of SL to fill these gaps, thereby improving motivation, engagement, and results.

The experiment conducted with 49 engineering students, divided into two distinct groups, was rich in lessons. The group that benefited from a SL approach, involving asynchronous group activities on forums and synchronous chat exchanges on the Moodle platform, demonstrated significantly higher levels of satisfaction and academic results than the group that had taken the course in the conventional way.

Throughout our experience, the active involvement of the teacher proved crucial in guiding discussions, providing timely feedback, and fostering an engaging learning atmosphere, highlighting the essential role of educators in online teaching.

These findings underscore the importance of integrating and encouraging social interactions to engage students in OL environments. This can enhance students' educational experience and, consequently, improve their academic performance.

Looking ahead, we plan to continue our study by integrating gamification elements into our experiments. By increasing the number of participating students, we aim to refine our results and further explore the synergies between different pedagogical approaches to design even more enriching e-learning environments. These perspectives aim to contribute to the constant evolution of educational practices and offer solutions that are increasingly adapted to learners' needs.

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