Exploring the Influence of Learner-To-Learner Interaction in Online Learning

Siti Farahin Binti Kamaruddin., Nadia Zalikha Binti Saifullizam., Azyan Zafyrah Binti Mohd Zahid., Noorashiekin Binti Khalid., Mazni Binti Mat Zin

Fakulti Kejuruteraan Awam, Universiti Teknologi MARA Cawangan Johor, Kampus Pasir Gudang

DOI: https://dx.doi.org/10.47772/IJRISS.2025.90900059

Received: 25 August 2025; Accepted: 31 August 2025; Published: 29 September 2025

ABSTRACT

The rise of online learning in higher education has intensified attention on the role of interaction in shaping student engagement and learning outcomes. Learner-to-learner interaction, has been recognized for its potential to enhance motivation, build community, and support deeper learning, yet its implementation often remains inconsistent. This study investigates how peer interaction contributes to online learning and how it relates to learner-to-instructor and learner-to-content engagement. The study employed a quantitative survey design, using a validated four-section instrument adapted from [1] covering demographics and the three interaction domains. A total of 94 undergraduate engineering students from a public university participated in the survey. Findings reveal that students value working with familiar peers and are more motivated to complete tasks when peer accountability is present. Strong positive correlations were found among all interaction types, suggesting that learner-to-learner engagement is closely linked to increased interaction with instructors and content. These results support the integration of well-designed peer collaboration into online course design and emphasize the importance of fostering multidirectional engagement to create inclusive, student-centered digital learning environments.

Keywords: learner-to-learner interaction, online learning, student engagement, connectivism, peer collaboration

INTRODUCTION

Background of Study

Online learning has become a prevalent educational modality in the digital age, radically altering the way that knowledge is offered and accessed in academic institutions. Interaction has become increasingly important as a key element of successful virtual learning experiences due to the increasing popularity of online and distance learning environments [1], [2].

According to [3], learner-to-learner interaction is essential for promoting deeper cognitive engagement, establishing social presence, and encouraging collaboration among the different forms of interaction. This type of interaction, which includes group projects, peer evaluations, peer discussions, and casual communication, increases students' emotional and intellectual commitment to the learning process [4].

Interaction between students is particularly crucial for reducing the feeling of loneliness that many students encounter in virtual learnings. Study suggests that meaningful peer collaboration not only enhances motivation and a sense of community but also facilitates the build of knowledge through shared experiences [5],[6]. Furthermore, when thoughtfully integrated into course design, peer interaction has been shown to increase learner satisfaction and improve academic outcomes[7].

Although huge research has explored online engagement and interaction, the dynamic and rapidly evolving nature of digital education continues to demand updated particularly in the post COVID-19 landscape where online learning has become mainstream. Technological advancements, shifts in instructional design, and the increasing diversity of learners underscore the need to revisit how learner-to-learner interaction functions

across varied educational contexts [8],[9]. Recent literature has also emphasized the importance of exploring the interrelationship between peer interaction and other interaction types, such as those between learners and instructors or content, to create more holistic and engaging learning environments [10].

Accordingly, this study contributes to the expanding discourse on online education by focusing specifically on the role and influence of learner-to-learner interaction. This study adds to the growing body of knowledge regarding online education by concentrating on the function and impact of learner-to-learner interaction. It seeks to investigate its immediate effects as well as its relationships with other types of interaction in the context of higher education, ultimately providing suggestions for improving cooperative, student-centred online learning environments.

Statement of Problem

Over the past decade, online learning has become a common way of education delivery within higher education, there has been an increased emphasis on the elements that make an online learning experience more quality, with a particular emphasis on the role of interaction. From three primary types of interaction (learner-to-learner, learner-to-instructor and learner-to-content), learner-to-learner interaction has gained increasing attention due to its ability to promote critical thinking, social presence, and collaborative learning[1], [5], [11].

Research has demonstrated that peer interaction contributes significantly to student motivation, engagement, and the formation of learning communities [4], [12]. However, despite its recognized importance, multiple studies have identified challenges that obstruct the effectiveness of peer collaboration in online environments. [13] reported that although students value collaboration, their actual participation in peer discussions is often limited by low motivation, unclear expectations, and weak group dynamics. Similarly, [14] found that many learners still experience feelings of loneliness and disconnection, indicating that current methods for encouraging interaction may not be inclusive or useful.

Further complicating the issue, [15] observed that online students often experience unclear collaboration structures and minimal responsiveness from peers, which can reduce opportunities for meaningful engagement and co-construction of knowledge. In their review, [7] emphasized that while peer interaction is commonly integrated into online course designs, its actual impact is highly dependent on instructional facilitation, technological support, and student preparedness. These findings suggest that the practical application of peer interaction in many online courses does not align with its theoretical value.

Moreover, although much of the literature has focused on studying each interaction in isolation, there is a growing need to explore their interrelated effects. [3] argue that understanding how learner-to-learner interaction functions in relation to learner-to-instructor and learner-to-content interaction is critical to creating a cohesive and engaging online learning environment. They also suggest that this understanding is especially important in diverse educational settings, including technical and STEM-based disciplines, where peer collaboration may be underutilized.

With these challenges, it is clear that learner-to-learner interaction must be examined in modern online learning environments. This includes exploring how peer interaction contributes to learning outcomes, and how it interrelates with instructor and content engagement. Addressing these gaps, the present study seeks to inform the design of more inclusive, student-centered, and effective online learning environments that facilitate deeper engagement and collaborative knowledge building.

Objective of the Study and Research Questions

The primary objective of this study is to explore the nature and influence of different types of interaction in online learning environments, with a particular focus on learner-to-learner interaction. This study aims to answer the following questions;

- How does learner-to-learner interaction influence online learning?
- How does learner-to-instructor interaction influence online learning?

● How does learner-to-content interaction influence online learning?

● Is there a relationship between learner-to-learner interaction and all types of interaction in online learning?

LITERATURE REVIEW

Theoretical Framework of the Study

*1) Theory of Connectivism:*In response to the difficulties associated with learning in the digital age, George Siemens created the theory of connectivism in 2005. According to Siemens, learning in a networked, technologically driven environment cannot be adequately explained by conventional learning theories like behaviorism, cognitivism, and constructivism. Connectivism highlights that learning occurs through connections with people, digital platforms, and information sources rather than being solely an individual activity [16].

Connectivism's core beliefs are that knowledge exists within systems and is accessed through networks, and that learning is the ability to navigate, grow, and utilize these networks effectively [17]. Meaningful learning involves creating and maintaining connections with other learners, experts, and digital content[18]. This theory aligns closely with the principles of online learning, where interaction is not confined to the physical classroom but occurs via forums, collaborative tools, multimedia, and real-time communication[19].

In the context of this study, connectivism offers a useful theoretical framework for comprehending how students interact with one another in virtual learning settings. Students interact with one another in discussion boards, peer evaluations, or group projects to create knowledge networks [20], [21]. These connections facilitate access to diverse perspectives and foster collective meaning-making, two core tenets of the connectivism approach, which enhance learning.

*2) Online Interaction in the Classroom:*Interaction has consistently been recognized as a foundational element of effective teaching and learning [22]. [23] introduced a groundbreaking typology of interaction for online learning environments, which has since been widely used and improved upon in further studies. His model categorizes interaction into three main categories: learner-to-learner (L2L), which includes group activities, peer collaboration, and discussions; learner-to-instructor (L2I), which includes student-teacher communication through clarification, feedback, and instructional support; and learner-to-content (L2C), which describes how students interact with instructional materials like texts, multimedia, and simulations.

[24] further argued that the presence of at least one type of interaction at a high level is sufficient to support meaningful learning in online environments. However, optimal outcomes are more likely when all three types are balanced. Recent empirical studies further support this view. For example,[1][19] and [3] have shown that a balanced integration of L2L, L2I, and L2C interactions leads to greater learner satisfaction, motivation, and academic achievement in virtual classrooms.

In addition to these foundational interaction types, researchers have introduced related constructs such as social presence, emotional engagement, and collaborative knowledge construction. These concepts, as discussed by [5] and [25], are particularly relevant to learner-to-learner interaction, as they emphasize the importance of peer relationships to encouraging participation, a sense of belonging and deeper learning.

A strong basis for this investigation is provided by the interaction framework put forth by Moore and others, as well as the theoretical foundations of connectivism. They stress how learning is social, connected, and dynamic by nature, particularly in online settings where students can engage meaningfully through ongoing interactions with teachers, peers, and course materials.

Past Studies

3) Past Studies on Online Interaction: Many studies have been conducted to investigate the role of interaction in shaping learner engagement and outcomes in online learning settings. The study by [1] strategies, with a particular emphasis on learner-to-learner and learner-to-instructor interaction. Involving 155 online

graduate students in the United States and using a quantitative Likert-scale survey, the findings showed that instructor interaction was rated the most important, while peer interaction was observed as less impactful. According to this, structured facilitation is necessary for peer interaction to be effective, even though it is frequently incorporated into online course designs. In contrast, the meta-analysis by [5] synthesized 17 studies and concluded that social presence, generated through learner-to learner interaction, significantly improve satisfaction and perceived learning, supporting the emotional value of peer engagement.

In support of these findings, [26] conducted an experimental study with 87 higher education learners to examine the impact of familiar versus unfamiliar peer presence during video-based learning. In comparison to learners learning alone or with unfamiliar peers, they discovered that learners paired with a familiar peer exhibited noticeably higher motivation, self-monitoring behavior, and performance based on eye-tracking, behavioral data, and post-tests. These findings suggest that passive or nonverbal peer presence can have a positive impact on emotional and cognitive engagement.

More recent research continues to explore the complex effects of learner-to-learner interaction. [27] investigated how peer interaction and emotional engagement contribute to students' continued intention to use asynchronous e-learning platforms. Surveying 259 learners, they discovered that peer interaction had a strong positive effect on learners' motivation and persistence, especially when instructor presence is delayed. In parallel, [28] investigated the validity of peer assessment in a postgraduate e-learning course and found that although peer grading was generally accurate, scores could be influenced by previous social relationships between students. This emphasizes a crucial difficulty in upholding equity in peer evaluation systems and necessitates careful instructional design.

Taken together, these studies consistently affirm that learner-to-learner interaction is an essential element in effective online learning. While it promotes motivation, community, and knowledge co-construction, its impact is conditional on context-specific variables such as peer familiarity, course structure, fairness, and support systems. Based on these observations, the current study intends to contribute to a more comprehensive understanding of engagement in digital higher education environments by investigating the impact of learner-to-learner interaction in relation to learner-to-instructor and learner-to-content interactions.

*4) Conceptual Framework of the Study:*When it comes to online learning, one of the main concerns would be; is there interaction? Just like a face-to-face traditional classroom, learners in online learning need attention from the instructor and their peers while they learn [29]. The attention gives them confidence in learning as well.

The theory of connectivism by [16] relates to the conditions for successful online learning. He states that online learners need to feel autonomy over the learning. They need to have connectedness with the instructor, their peers and the learning materials. Lastly, they need to be exposed to diversity and openness when it comes to learning materials.

Fig.1 shows the conceptual framework of the study. This study replicates the study by [1] who presented three types of interaction in online learning. The first type is learner-to-learner interaction. Even in online learning, learners need to feel connected to their peers. This is usually obtained through class discussion or even group interaction. Next, the presence of the instructor is still needed in online learning. The instructor provides direction to the online session. Finally, the last type of interaction is learner-to-content interaction. The instructor can plan lessons so that learners are able to understand the content better. Activities about the content of the lesson be it serious academic task or fun interesting activities can help learners make sense of the text.

This study also explores the relationship between learner-to-learner and learner-to-instructor interaction. This study also explores if there is a relationship between learner-to-instructor and learner-to-content interaction. Finally, this study also looks at the relationship between learner-to-content and learner-to-learner interaction.

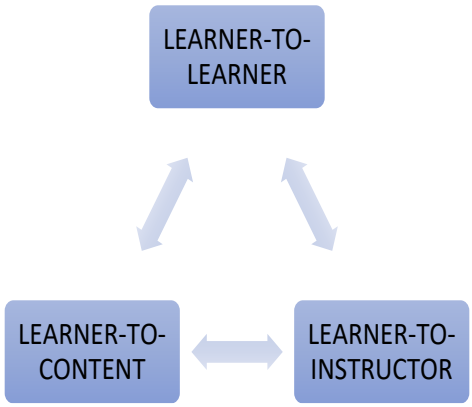

Fig.1 Conceptual Framework of the Study- The Influence of Learner-to-learner Interaction in online learning

METHODOLOGY

This quantitative study is done to explore interactions in online learning. A convenient sample of 94 participants responded to the survey. The instrument used is a 5 Likert-scale survey. Table 1 below shows the categories used for the Likert scale; 1 is for Strongly Disagree, 2 is for Disagree, 3 is for Undecided, 4 is for Agree and 5 is for Strongly Agree.

Table I Likert Scale Use

1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Table 2 shows the distribution of items in the survey. The instrument is replicated from [1] to reveal the variables in the table below. Section B has 5 items on learner-to-learner interaction. Section C has 7 items on learner-to-instructor interaction and section D has 7 items on learner-to-content interaction.

Table II Distribution of Items in the Survey

SECTION	TYPE OF INTERACTION	No of Items	Cronbach Alpha
B	Learner-to-Learner	5	.885
C	Learner-to-Instructor	7	.910
D	Learner-to-Content	7	.885
	Tot no. of Item	19	.949

Table 2 also shows the reliability of the survey. The analysis shows a Cronbach Alpha of .885 for learner-to-learner interaction, .910 for learner-to-instructor interaction and .885 for learner-to-content interaction. The overall Cronbach Alpha for all 19 items is .949; thus, revealing a good reliability of the instrument used. The results are presented after further analysis with SPSS to address the study's research questions.

FINDINGS

Demographic Analysis

Table III Percentage for Demographic Profile

Question	Demographic Profile	Categories	Percentage (%)
1	Gender	Male	50%
		Female	50%
2	Semester	Part 1-2	18%
		Part 3-4	55%
		Part 5-6	22%
		Part 7-8	5%
3	College of Engineering	Civil	68%
		Electrical	19%
		Mechanical	9%
		Chemical	4%
4	Learning Location	Home	18%
		College	82%
5	Internet Access	Slow	5%
		Medium	65%
		Strong	30%

Table 3 summarizes the demographic profile of the respondents. In terms of gender distribution, the sample was evenly split, with 50% male and 50% female participants. Most respondents were in Part 3-4 of their studies (55%), followed by Part 5-6 (22%) and Part 1-2 (18%), while only 5% were from Part 7-8. Most students were from the Civil Engineering program (68%), followed by Electrical Engineering (19%), Mechanical Engineering (9%), and Chemical Engineering (4%). Regarding learning location, a significant portion of students (82%) attended classes from college, while only 18% studied from home. As for internet access, the majority reported having medium access (65%), followed by strong (30%), and a small percentage (5%) indicated slow connectivity. These results provide a full overview of the participants' backgrounds, that may influence their engagement with online learning environments.

Descriptive Statistics

*5) Findings for Learner-to-Learner Interaction:*This section presents data to answer research question 1- How does learner-to-learner interaction influence online learning?

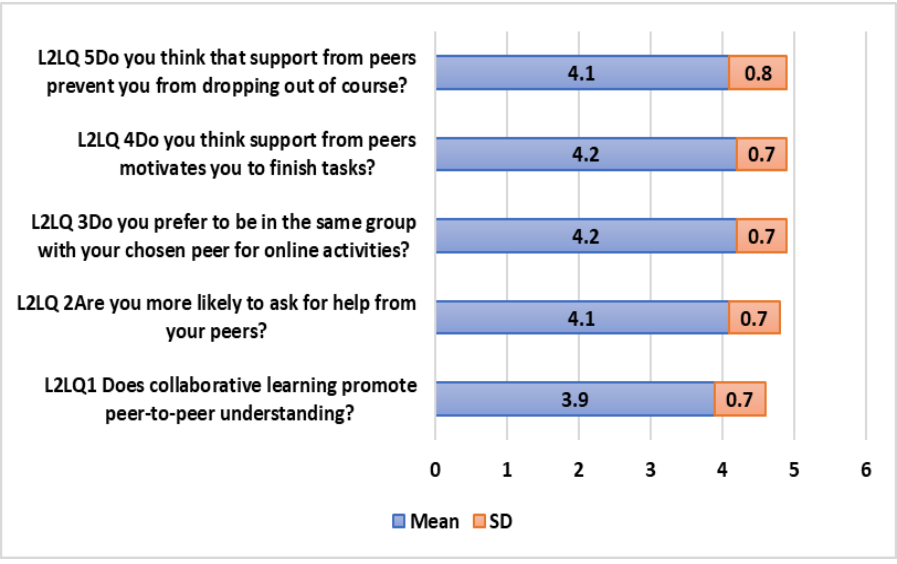

Fig. 2 Mean for Learner-to-Learner Interaction

Fig. 2 shows the mean for learner-to-learner interaction. Two items share the same highest mean for 4.2. The first is item 3 (mean=4.2,SD=0.7) and it shows learners preference to be in the same group as their chosen peer. Next is item 4 (Mean=4.2,SD=0.7) and it reveals how leaners saw their peers as motivating factor to complete the given task. The lowest item is number 1 (mean=3.9,SD=0.7) and it shows how learners felt that collaborative learning promote peer-to-peer understanding.

*6) Findings for Learner-to-Instructor:*This section presents data to answer research question 2- How does learner-to-instructor interaction influence online learning?

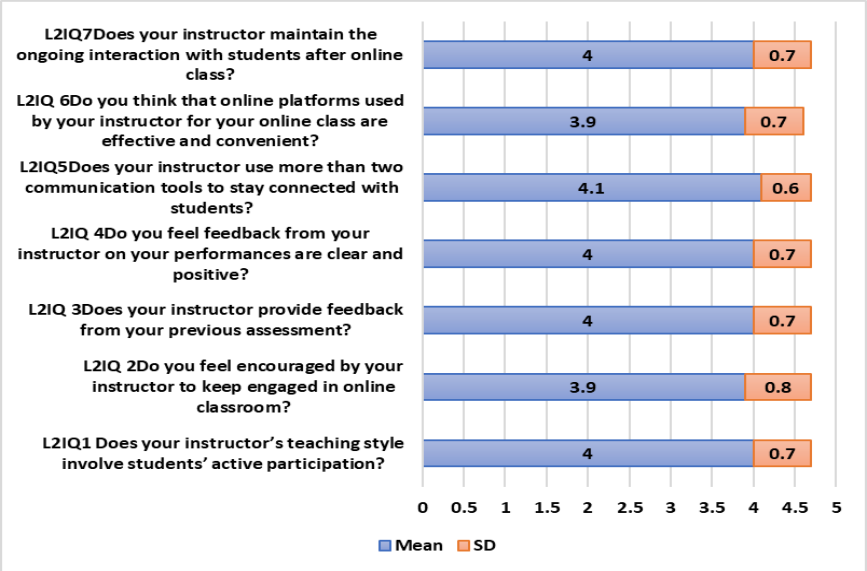

Fig. 3 Mean for Learner-to-Instructor Interaction

Fig. 3 presents the mean scores for learner-to-instructor interaction. The highest mean score is found in item 5 (Mean = 4.1, SD = 0.6), which indicates that learners agree their instructor uses more than two communication tools to stay in touch with them. In contrast, the lowest mean score is shared by items 2 and 6, both scoring a mean of 3.9. Item 2 (SD = 0.8) reflects students' perceptions of encouragement from instructors to stay engaged in the online classroom, while item 6 (SD = 0.7) reflects their view on the effectiveness and convenience of the online platforms used.

7) Findings for Learner-to-Content: This section presents data to answer research question 3- How does learner-to-content interaction influence online learning?

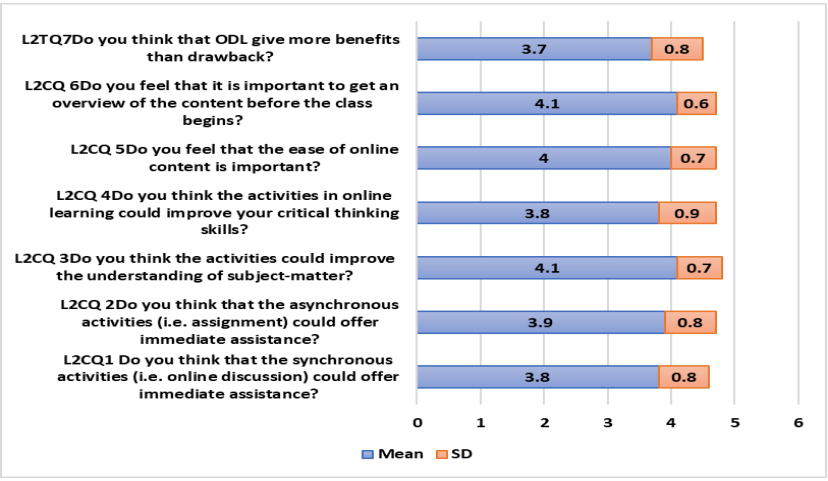

Fig. 4 Mean for Learner-to-Content Interaction

Fig. 4 shows the mean value for learner-to-content interaction. Two items share the same highest mean of 4.1. The first is item 3 (Mean = 4.1, SD = 0.7) and it shows learners' belief that the activities could enhance their comprehension of the material. The second is item 6 (Mean = 4.1, SD = 0.6), which reflects how important for learners to get an overview of the content before the class begins. The lowest mean is found in item 7 (Mean = 3.7, SD = 0.8), which shows how learners felt about ODL (Open and Distance Learning) offered more advantages than disadvantages. This suggests that while learners have a generally positive opinion of the content, they may still have doubt about the overall effectiveness of the ODL approach.

Exploratory Statistics

Findings the connection between learner-to-learner interaction and all types of interaction in online learning. This section presents data to answer research questions 4- Is there a relationship between learner-to-learner interaction and all types of interaction in online learning?

To determine if there is a significant relationship in the mean scores between learner-to-learner interaction and all types of interaction in online learning, data is anlaysed using SPSS for correlations. Results are presented separately in Table 4, 5 and 6 below.

Table IV Correlation between Learner-to-Learner and Learner-to-Instructor Interaction

		LEARNER-TO-LEARNER	LEARNER-TO-INSTRUCTOR
LEARNER-TO-LEARNER	Pearson (Correlation	1	.639**
	Sig (2-tailed)		.000
	N	94	94
LEARNER-TO-INSTRUCTOR	Pearson (Correlation	.639**	1
	Sig (2-tailed)	.000	
	N	94	94

**Correlation is significant at the 0.01 level (2-tailed)

A correlation between learner-to-learner and learner-to-instructor interaction is demonstrated in Table 4. The results of correlation analysis indicate that there is a high significant association between learner-to-learner and learner-to-instructor interaction (r=.639**) and (p=.000). According to [30], coefficient is significant at the .05 level and positive correlation is measured on a 0.1 to 1.0 scale. Weak positive correlation would be in the range of 0.1 to 0.3, moderate positive correlation from 0.3 to 0.5, and strong positive correlation from 0.5 to 1.0. This means that there is also a strong positive relationship between learner-to-learner and learner-to-instructor interaction.

Table V Correlation between Learner-to-Instructor and Learner-to-Content Interaction

		LEARNER-TO-INSTRUCTOR	LEARNER-TO-CONTENT
LEARNER-TO-INSTRUCTOR	Pearson (Correlation	1	.773**
	Sig (2-tailed)		.000
	N	94	94
LEARNER-TO-CONTENT	Pearson (Correlation	.773**	1
	Sig (2-tailed)	.000	
	N	94	94

**Correlation is significant at the 0.01 level (2-tailed)

Table 5 shows a correlation between learner-to-content interaction and learner-to-instructor interaction. The results of correlation analysis indicate that there is a highly significant association between learner-to-

instructor and learner-to-content interaction (r=.773**) and (p=.000). According to [30], coefficient is significant at the .05 level and positive correlation is measured on a 0.1 to 1.0 scale. Weak positive correlation would be in the range of 0.1 to 0.3, moderate positive correlation from 0.3 to 0.5, and strong positive correlation from 0.5 to 1.0. This means that there is also a strong positive relationship between learner-to-instructor and learner-to-content interaction.

Table VI Correlation between Learner-to-Content and Learner-to-Learner Interaction

		LEARNER-TO-CONTENT	LEARNER-TO-LEARNER
LEARNER-TO-CONTENT	Pearson (Correlation	1	.741**
	Sig (2-tailed)		.000
	N	94	94
LEARNER-TO-LEARNER	Pearson (Correlation	.741**	1
	Sig (2-tailed)	.000	
	N	94	94

**Correlation is significant at the 0.01 level (2-tailed)

Table 6 reveals that there is an association between learner-to-learner and learner-to-content interaction. Correlation analysis shows that there is a high significant association between learner-to-learner and learner-to-content interaction (r=.741**) and (p=.000). According to [30], coefficient is significant at the .05 level and positive correlation is measured on a 0.1 to 1.0 scale. Weak positive correlation would be in the range of 0.1 to 0.3, moderate positive correlation from 0.3 to 0.5, and strong positive correlation from 0.5 to 1.0. This means that there is also a strong positive relationship between learner-to-learner and learner-to-content interaction.

CONCLUSION

Summary of Findings and Discussions

This study explored the nature and impact of different types of interaction in online learning environments, with a particular emphasis on learner-to-learner (L2L) interaction. The results provided valuable insight into how peer, instructor, and content engagement form learners' experiences, and how these forms of interaction relate to one another to promote a cohesive virtual learning environment.

RQ1: How does learner-to-learner interaction influence online learning?

The findings demonstrate that learner-to-learner interaction plays a crucial role in enhancing students' motivation and sense of connection in online learning environments. Participants expressed strong agreement with items related to peer collaboration, especially the ability to work alongside preferred peers and feeling encouraged by classmates to complete tasks. According to these findings, peer accountability and social familiarity serve as important motivators in online group environments.

Despite their appreciation of peer collaboration, students showed relatively little faith in their ability to foster conceptual clarity or deep understanding. This suggests that there may be a discrepancy between cognitive development and emotional involvement in peer settings. These observations align with the findings of [5], who related peer interaction with stronger emotional investment, and [26], who highlighted that peer presence supports concentration and self-regulation. Although [1] observed that students sometimes view peer interaction as less impactful than instructor support, this study affirms the importance of peer interaction when it is effectively incorporated into the course structure.

RQ2: How does learner-to-instructor interaction influence online learning?

The findings highlight the importance of instructor presence and communication in shaping students' online learning experiences. Learners indicated that they appreciated instructors who made consistent efforts to stay connected, mostly when multiple communication tools were used to maintain accessibility and engagement.

This implies that regular and varied interactions with instructors create a nurturing atmosphere that helps learners feel supported and recognized even when they are physically separated by online platforms.

However, participants were slightly less positive about the effort of encouragement they received to stay actively engaged, as well as their perceptions of the platforms' convenience for interaction. This suggests that although instructor availability is appreciated, its effectiveness is contingent upon the responsiveness, clarity, and strategy of communication. These findings reflect previous studies by [1], who found that instructor interaction is one of the most important factors in online engagement, and [3], who highlighted the emotional support offered by active instructor involvement. Together, the results affirm that learner-instructor communication is essential to motivation and satisfaction in online classrooms but must be deliberate and learner centered to be fully effective.

RQ3: How does learner-to-content interaction influence online learning?

The findings indicate that learner-to-content interaction is a critical driver of understanding and engagement in online learning. Participants expressed strong appreciation for structured and accessible content, particularly when activities were designed to deepen subject comprehension and when they were provided with clear overviews prior to lessons. These elements appear to help learners navigate online coursework more confidently and with better preparedness, highlighting the value of intentional instructional design in supporting cognitive engagement.

Despite these positive perceptions, students showed some hesitation regarding the broader benefits of open and distance learning (ODL), suggesting a degree of skepticism about its effectiveness when compared to traditional modalities. This reflects earlier findings by [3], who emphasized the need for clarity, coherence, and relevance in content to maximize cognitive engagement. [7] similarly noted that learner-to-content interaction plays a foundational role in promoting independent learning, but its success depends heavily on the quality and structure of instructional materials. These insights reaffirm that engaging content is essential, but it must be accompanied by clear expectations and learner centered delivery to fully support online learning outcomes.

RQ4: Is there a relationship between learner-to-learner interaction and all types of interaction in online learning?

The findings indicate that learner-to-learner interaction is strongly interconnected with both learner-to-instructor and learner-to-content interactions. When students actively engage with their peers, they are also more likely to interact meaningfully with instructors and engage more deeply with course content. This suggests that peer engagement does not occur in isolation but functions within a broader ecosystem of learning relationships that reinforce one another in virtual classrooms.

These results support existing research that highlights the multidimensional nature of interaction in online education. [3] emphasized the need to understand how different interaction types relate and influence overall learner engagement. Likewise, [7] found that successful online learning experiences are built not only on isolated strategies but on integrated designs that foster dynamic interaction across peer, instructor, and content domains. The findings of this study reaffirm that fostering learner-to-learner interaction can have benefits, enhancing communication with instructors and promoting deeper content engagement. Thus, contributing to a more holistic and engaging online learning experience.

Implications and Suggestions for Future Research

*8) Theoretical and Conceptual Implications:*The findings of this study reinforce the theoretical foundation of connectivism as proposed by [16], which emphasizes the value of learning through networks, collaboration, and digital engagement. The demonstrated relationships between learner-to-learner, learner-to-instructor, and learner-to-content interactions align with the principles of connectivism, wherein meaningful learning emerges from diverse and connected learning experiences [18]. Moreover, the positive associations found between these interaction types validate [23] interaction framework and [24] argument that high-quality online learning is sustained when at least one form of interaction is meaningfully developed. The conceptual framework used in this study, which integrates these theoretical models, is therefore empirically supported. These results

underscore the importance of designing online environments that foster multidirectional engagement and strengthen the social, instructional, and content dimensions of the learning process.

*9) Pedagogical Implications:*The findings of this study offer several practical implications for online teaching and course design. First, the strong learner preference for peer collaboration and motivational support suggests that instructors should intentionally integrate collaborative activities, such as group discussions and peer feedback sessions, into the curriculum [3], [5]. These strategies help promote social presence and emotional engagement, reducing feelings of isolation and enhancing the sense of community.

Second, the observed correlation between learner-to-learner and learner-to-instructor interaction highlights the critical role of instructor presence. Instructors must remain consistently communicative and approachable through multiple channels such as announcements and feedback to get student trust and engagement [1],[27]. Supporting students with timely feedback and guidance is particularly crucial in maintaining motivation in asynchronous learning environments.

Third, learner-to-content interaction, while positively rated, revealed variability in how students perceive the relevance of content. This suggests a need for more engaging, interactive content that allows students to explore material at their own pace while applying concepts to real world contexts [7]. Integrating multimedia tools and personalized learning paths may help bridge this gap and deepen cognitive engagement.

*10) Suggestions for Future Research:*While this study advances our understanding of online interactions among higher education learners, it also opens several paths for future research. One direction would be to explore how discipline specific instructional strategies influence the quality and depth of peer interaction. This is particularly relevant in STEM disciplines, where collaborative learning is often underutilized despite its potential to enhance critical thinking and problem-solving skills [15].

Moreover, future research should examine how emotional and motivational engagement mediate the relationship between interaction types and academic achievement. Given the strong correlation between peer support and learner persistence identified in this study, it is essential to consider how individual learner characteristics, such as personality, digital literacy levels, and sociocultural backgrounds will influence engagement and interaction behaviors in online learning communities.

Finally, integrating qualitative insights from both learners and instructors can offer a more comprehensive understanding of how interactions are viewed and experienced in virtual environments. Our comprehension of the contextual and affective aspects of learning can be strengthened by such viewpoints, which can also help us create more responsive and inclusive pedagogical frameworks that encourage meaningful engagement for all learners.

ACKNOWLEDGMENT

The author gratefully acknowledges the support of individuals and organizations that provided the resources necessary for this study. Appreciation is also extended to colleagues and peers whose insights and encouragement have been invaluable throughout the research and writing process.

REFERENCES

1. D. . Martin, F. & Bolliger, “Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment,” Online Learn., vol. 22, no. 1, pp. 205–222, 2018.
2. M. Chung, J., McKenzie, S., Schweinsberg, A., & Mundy, “Correlates of academic performance in online higher education: a systematic review,” Front. Educ., vol. 7, 2021, doi: 10.3389/feduc.2022.820567.
3. R. Sun, J. C. and Rueda, “Situational interest, computer self-efficacy and self-regulation: their impact on student engagement in distance education,” Br. J. Educ. Technol., vol. 43, no. 2, pp. 191–204, 2012, doi: 10.1111/j.1467-8535.2010.01157.x.
4. A. Martin, F., Wang, C., & Sadaf, “Student perception of helpfulness of facilitation strategies that

enhance instructor presence, connectedness, engagement and learning in online courses," Internet High. Educ., vol. 37, pp. 52–65, 2018, doi: 10. 1016/j. iheduc. 2018. 01. 003.
5. S. Richardson, J., Maeda, Y., Lv, J., & Caskurlu, "Social presence in relation to students' satisfaction and learning in the online environment: a meta-analysis," Comput. Human Behav., vol. 71, pp. 402–417, 2017, doi: 10.1016/j.chb.2017.02.001.
6. H. Fiock, "Designing a community of inquiry in online courses," Int. Rev. Res. Open Distrib. Learn., vol. 21, no. 1, pp. 134–152, 2020, doi: 10.19173/irrodl.v20i5.3985.
7. C. D. Martin, F., Sun, T., & Westine, "A systematic review of research on online teaching and learning from 2009 to 2018," Comput. Educ., p. 159, 2020, doi: 10.1016/j.compedu.2020.104009.
8. A. Hamdan, K. M., Al-Bashaireh, A. M., Zahran, Z., Al-Daghestani, A., AL-Habashneh, S., & Shaheen, "University students' interaction, internet self-efficacy, self-regulation and satisfaction with online education during pandemic crises of covid-19 (sars-cov-2)," Int. J. Educ. Manag., vol. 35, no. 3, pp. 713–725, 2021, doi: 10.1108/ijem-11-2020-0513.
9. R. Kara, M., Kukul, V., & Çakır, "Self-regulation in three types of online interaction: how does it predict online pre-service teachers' perceived learning and satisfaction?," Asia-Pacific Educ. Res., vol. 30, no. 1, pp. 1–10, 2021, doi: 10.1007/s40299-020-00509-x.
10. N. J. Devos, "Uncovering Peer Interactions as a Resource for Learning," Springer Int. Publ., pp. 87–106, 2016, doi: 10.1007/978-3-319-22219-6_.
11. Y. Yang, "Engaging students in an online situated language learning environment," Comput. Assist. Lang. Learn., vol. 24, no. 2, pp. 181–198, 2012, doi: 10.1080/09588221.2010.538700.
12. S. Shin, H. W., & Sok, "Student satisfaction and perceived learning in an online second language learning environment: A replication of Gray and DiLoreto (2016)," ReCALL, vol. 35, no. 2, pp. 160–177, 2023, doi: 10.1017/S0958344023000034.
13. E. Alqurashi, "Predicting student satisfaction and perceived learning within online learning environments," Distance Educ., vol. 40, no. 1, pp. 133–148, 2019, doi: 10.1080/01587919.2018.1553562.
14. J. S. Baloran, E. T., Hernan, J. T., & TAOY, "Course satisfaction and student engagement in online learning amid covid-19 pandemic: a structural equation model," Turkish Online J. Distance Educ., pp. 1–12, 2021, doi: 10.17718/tojde.1002721.
15. Y. T. Kuo, Y. C., Tseng, H., and Kuo, "Internet Self-Efficacy, Self-Regulation, and Student performance: African-American Adult Students in Online Learning," Int. J. E-Learning Corp. Gov. Heal. High. Educ, vol. 19, no. 2, pp. 161–180, 2020.
16. G. Siemens, "Connectivism: A Learning Theory for the Digital Age," Int. J. Instr. Technol. distance Learn., vol. 2, no. 1, 2005.
17. I. Ismail, "Exploring modern educational theories: a literature review of student learning in the digital age," Int. J. Multidiscip. Sci., vol. 3, no. 3, pp. 83–94, 2024, doi: 10.56127/ijml.v3i3.1646.
18. S. Downes, "Recent Work in Connectivism," Eur. J. Open, Distance E-Learning, vol. 22, no. 2, pp. 113–132, 2019, doi: 10.2478/EURODL-2019-0014.
19. G. Keengwe, J., & Schnellert, "Fostering Interaction to Enhance Learning in Online Learning Environments," Int. J. Inf. Commun. Technol. Educ., vol. 8, no. 3, pp. 28–35, 2012, doi: 10.4018/JICTE.2012070104.
20. E. Corbett, F., & Spinello, "Connectivism and leadership: harnessing a learning theory for the digital age to redefine leadership in the twenty-first century," Heliyon, vol. 6, no. 1, 2020, doi: 10.1016/J.HELIYON.2020.E03250.
21. N. H. Haris, M. H. M., Husin, S. F., Rosli, R., & Rahmat, "Is there Connectivism in Online Engagement?," Int. J. Acad. Res. Bus. Soc. Sci., 2023, doi: 10.6007/ijarbss/v13-i8/17736.
22. N. Hussin, W., Harun, J., & Shukor, "Online interaction in social learning environment towards critical thinking skill: a framework," J. Technol. Sci. Educ., vol. 9, no. 1, p. 4, 2019.
23. M. G. Moore, "Editorial: three types of interaction," Am. J. Distance Educ., vol. 3, no. 2, pp. 1–7, 1989, doi: 10.1080/08923648909526659.
24. T. Anderson, "Getting the mix right again: An updated and theoretical rationale for interaction.," Int. Rev. Res. Open Distrib. Learn., vol. 4, no. 2, 2003, doi: 10.19173/irrodl.v4i2.149.
25. Y. Gherghel, C., Yasuda, S., & Kita, "Interaction during online classes fosters engagement with learning and self-directed study both in the first and second years of the COVID-19 pandemic," Comput. Educ.,

p. 200, 2023, doi: 10.1016/j.compedu.2023.104795.
26. J. Pi, Z., Zhang, Y., Yu, Q., & Yang, "A familiar peer improves students' behavior patterns, attention, and performance when learning from video lectures," Int. J. Educ. Technol. High. Educ., vol. 20, no. 1, p. 47, 2023, doi: 10.1186/s41239-023-00418-1.
27. M. H. Alshammari, S. H., & Alshammari, "Modeling the effects of emotional engagement and peer interaction on students' continuous intention to use asynchronous e-learning," PeerJ Comput. Sci., vol. 10, 2024, doi: 10.7717/peerj-cs.1990.
28. D. Sousa, F., Alves, T., Gama, S., Jorge, J., & Gonçalves, "Studying how social relationships affect peer assessment in an e-learning environment," Learn. Environ. Res., vol. 27, pp. 797–817, 2024, doi: 10.1007/s10984024095050.
29. E. S. Rahmat, N. H. ., Sukimin, I. S. ., Sim, M. S. ., Anuar, M. ., & Mohandas, "Online Learning Motivation and Satisfaction: A Case Study of Undergraduates vs Postgraduates," Int. J. Asian Soc. Sci., vol. 11, no. 2, pp. 88–97, 2021, doi: 10.18488/journal.1.2021.112.88.97.
30. S. L. Jackson, Research methods and Statistics-A Critical Thinking Approach, 5th ed. Boston,USA: Cengage Learning, 2015.