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RECEIVED 19 December 2025

REVISED 27 March 2026

ACCEPTED 06 April 2026

PUBLISHED 01 May 2026







### CITATION

Macías Rodríguez LE, Santana Estrella RE, García Carranza EK, Rybarczyk Y, Vera F and Facuy Delgado JP (2026) The role of educational presence in enhancing synchronous and asynchronous interactivity in virtual learning environments.  
Front. Educ. 11:1771906.  
doi: 10.3389/feduc.2026.1771906

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# The role of educational presence in enhancing synchronous and asynchronous interactivity in virtual learning environments

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**Introduction:** This study examines the role of interactivity in virtual learning environments (VLEs), focusing on the integration of synchronous and asynchronous modalities in shaping educational presence.

**Methods:** A mixed-methods design was applied, combining survey data, observational analysis, and interaction records from a Moodle-based course with 115 undergraduate Communication students. Variables included participation patterns, cognitive engagement, and access to technological resources.

**Results:** Synchronous interaction enhances teaching and social presence through immediacy and real-time feedback, while asynchronous interaction supports cognitive presence by fostering reflection and deeper engagement. These effects are conditioned by communication strategies and contextual factors, including technological access and socioeconomic conditions.

**Discussion:** Interactivity emerges as a context-dependent process rather than a direct causal mechanism. The study proposes the concept of Strategic Educational Presence, extending the Community of Inquiry framework by incorporating a communicational and strategic dimension. This approach underscores the alignment of interaction modalities, pedagogical design, and contextual conditions to support meaningful learning. Limitations include a single institutional context and reliance on self-reported data. Future research should test this framework across disciplines using longitudinal and multivariate approaches.

### KEYWORDS

didactic strategies, digital communication, educommunication, interactivity, online learning, virtual environments

## 1 Introduction

The rapid expansion of virtual learning environments (VLEs) has significantly transformed higher education, reshaping how interaction, communication, and knowledge construction occur in digital contexts. In this scenario, interactivity has been widely recognized as a central component of effective online learning, influencing student engagement, cognitive development, and learning outcomes. Recent empirical

studies emphasize that interaction plays a critical role in sustaining meaningful learning experiences and collaborative knowledge construction in digital environments (Reyes et al., 2023; Villanueva et al., 2023).

The integration of synchronous and asynchronous modalities has enabled more flexible and adaptive learning experiences. Evidence suggests that synchronous interaction enhances immediacy and social presence, while asynchronous environments promote reflection and deeper cognitive engagement (Bryson and Andres, 2023). However, despite these advances, literature has largely examined these modalities as separate or complementary components, without sufficiently addressing their strategic integration as communicative processes within virtual learning environments.

The Community of Inquiry (CoI) framework (Garrison et al., 2000) remains one of the most widely used models for analyzing online learning, structuring educational experiences through cognitive, social, and teaching presence. Recent studies continue to validate the relevance of these dimensions and their interrelationships in shaping meaningful learning outcomes and instructional design (Chim et al., 2024; Richardson et al., 2025). Moreover, emerging research has expanded the application of the CoI framework to diverse educational contexts, including asynchronous environments and multimodal learning scenarios, reinforcing its adaptability while also highlighting the need for further conceptual development (Olesova et al., 2026; Smith and Storrs, 2023).

Despite its widespread adoption, the application of the CoI framework has often remained predominantly descriptive, with limited efforts to examine how interaction modalities actively configure educational presence in context-specific settings. There is a lack of research addressing how synchronous and asynchronous interactivity function as strategic communication processes that shape educational presence, especially within disciplinary contexts such as communication studies.

This gap becomes more evident when considering contextual variables such as technological access and socioeconomic conditions. Recent research highlights that inequalities in access to digital infrastructure and technological resources significantly affect participation and interaction patterns in virtual learning environments (Zhang and Ramakrishnan, 2023). However, these factors are frequently treated as external constraints rather than analytically integrated components of interactivity, limiting the development of more comprehensive explanatory models.

To address these limitations, this study introduces the concept of Strategic Educational Presence, defined as the intentional configuration of interaction modalities, communication practices, and pedagogical design to enhance learning processes in virtual environments. This perspective extends the CoI framework by incorporating a communicational and strategic dimension, enabling a more integrated understanding of how synchronous and asynchronous interactions contribute to meaningful learning experiences.

Methodologically, this research adopts a mixed-methods approach within a case study conducted in a higher education program in Communication Studies. The study combines survey data, observational analysis, and interaction records from a virtual platform (Moodle) to examine how interactivity influences educational presence. Key variables—including technological access (internet connectivity, device availability),

participation patterns, and perceptions of cognitive engagement—are operationalized through structured instruments and validated indicators.

Based on this framework, the study is guided by the following research questions:

- **RQ1:** How do synchronous and asynchronous interaction modalities differentially influence the dimensions of educational presence in virtual learning environments?
- **RQ2:** To what extent do communication strategies mediate the relationship between interactivity and educational presence?
- **RQ3:** How do technological and socioeconomic factors condition the effectiveness of interactive processes in VLEs?

This study contributes to literature in three main ways. First, it advances a theoretical contribution by extending the CoI framework through the integration of strategic communication and interaction modalities. Second, it offers an empirical contribution by examining interactivity within a real-world context shaped by technological and socioeconomic constraints. Third, it provides practical implications for instructional design, emphasizing the need for context-sensitive integration of synchronous and asynchronous activities.

## 2 Literature review

### 2.1 Interactive communication in virtual learning environments

Interactive communication in virtual learning environments (VLEs) has been increasingly conceptualized as a multidimensional construct integrating cognitive, behavioral, and affective dimensions that shape student engagement and learning outcomes. Contemporary research emphasizes that interactivity should be understood not merely as a technological affordance but as a pedagogically mediated process embedded within digital learning ecosystems (Doo et al., 2023; Gao et al., 2024; Li, 2023). Interactive communication involves multidirectional exchanges among learners, instructors, and digital platforms, facilitating knowledge co-construction and collaborative learning. Empirical evidence indicates that interaction significantly enhances learning efficiency, particularly when mediated by social presence and engagement processes (Gao et al., 2024; Nungu et al., 2023). Additionally, dialogic and empathetic communication has been shown to strengthen interaction quality and foster meaningful learning experiences (Patel, 2023).

Recent research highlights the importance of psychological and contextual variables in shaping interaction. For example, social connectedness, emotional expression, and humor significantly influence social presence and perceived engagement (Özdoğan et al., 2025; Yeung et al., 2023). Likewise, students' perceptions of VLEs are shaped by instructional design, disciplinary context, and interaction practices (Park and Sohn, 2023; Pavlou, 2024). Furthermore, social media and collaborative environments can enhance interaction and academic performance when effectively

integrated into learning design (Almogren, 2023). From a broader perspective, interaction quality is also conditioned by institutional and technological factors, including digital access, platform affordances, and pedagogical strategies (Maphosa and van den Berg, 2023; Haleem et al., 2022).

### 2.1.1 Interactivity in synchronous learning spaces

Synchronous learning environments enable real-time interaction, fostering immediacy and social presence. Empirical evidence suggests that real-time communication enhances engagement, perceived instructor support, and relational connection (Li, 2023; Wempe and Collins, 2024). However, immediacy alone does not ensure deeper cognitive engagement. Instead, learning effectiveness depends on instructional design, interaction quality, and the integration of meaningful dialogue (Di Natale et al., 2024; Gao et al., 2024). Studies comparing synchronous technologies, such as videoconferencing and virtual reality, indicate that immersive and interactive features can further enhance engagement when pedagogically aligned (Di Natale et al., 2024). Synchronous interaction is influenced by contextual constraints such as connectivity, digital skills, and access to devices, which shape participation and equity in learning experiences (Mazzeo et al., 2025; Zhang et al., 2025).

### 2.1.2 Interactivity in asynchronous learning spaces

Asynchronous environments provide flexibility and opportunities for reflection, supporting deeper cognitive processing and self-regulated learning. Research indicates that structured asynchronous interaction enhances critical thinking, engagement, and knowledge construction (Gao et al., 2024; Miao and Ma, 2022). Moreover, asynchronous communication tools facilitate continuous interaction and collaborative learning beyond real-time constraints. These environments support sustained engagement through discussion forums, messaging systems, and feedback mechanisms (Rababah and Rababah, 2024; Rasikawati et al., 2024). However, their effectiveness depends on instructional scaffolding, feedback quality, and communication design to prevent disengagement and cognitive overload (Lee and Kim, 2023).

## 2.2 Educational presence and its theoretical expansion

Educational presence remains central to understanding interaction in VLEs; however, recent research suggests that it should be reconceptualized as a multidimensional and context-dependent construct. Empirical evidence shows that social presence is shaped by affective, relational, and communicative dimensions rather than solely by interaction frequency (Özdoğru et al., 2025; Pham et al., 2023). Similarly, teaching and social presence have been found to significantly influence learners' psychological needs, engagement, and satisfaction (Doo et al., 2023; McNeill and Bushaala, 2023). Furthermore, the integration of the Community of Inquiry

framework across different contexts highlights its adaptability while also revealing the need for theoretical expansion (Yidana and Aboagye, 2024). Emerging research also indicates that digital and immersive technologies extend the concept of presence by introducing experiential and multimodal dimensions to interaction (Di Natale et al., 2024).

### 2.2.1 Cognitive presence

Cognitive presence refers to learners' ability to construct meaning through sustained reflection and interaction. Empirical studies confirm that collaborative and interactive learning environments significantly enhance knowledge construction when supported by structured pedagogical strategies (Gao et al., 2024; Nungu et al., 2023).

### 2.2.2 Social presence

Social presence reflects the extent to which learners perceive others as socially and emotionally real in virtual environments. It plays a central mediating role in engagement, interaction, and satisfaction. Recent findings indicate that social presence is influenced by emotional expression, communication design, and relational dynamics (Özdoğru et al., 2025; Yeung et al., 2023). Additionally, technological affordances such as video interaction and collaborative tools enhance perceptions of presence (Wempe and Collins, 2024).

### 2.2.3 Teaching presence

Teaching presence includes instructional design, facilitation, and communication strategies that guide learning processes. It is a key determinant of interaction quality and engagement. Research shows that effective teaching presence requires intentional communication design, continuous feedback, and the integration of interactive strategies to support learning outcomes (Doo et al., 2023; Li, 2023). Furthermore, instructor facilitation plays a critical role in fostering meaningful interaction and sustaining engagement (McNeill and Bushaala, 2023).

## 2.3 Communication strategies in virtual learning environments

Communication strategies in VLEs should be conceptualized as structured systems that integrate multiple interaction modalities. Empirical evidence suggests that effective strategies include structured dialogue, collaborative interaction, continuous feedback, and multimodal communication (Patel, 2023; Rababah and Rababah, 2024). Hybrid and blended approaches that combine synchronous and asynchronous interaction have been shown to enhance engagement and learning outcomes when aligned with pedagogical objectives (Gao et al., 2024; Zhang et al., 2025). However, the effectiveness of these strategies depends on contextual factors such as digital literacy, technological access, and institutional support (Almogren, 2023; Maphosa and van den Berg, 2023).

## 2.4 Conceptual contribution: strategic educational presence

Based on the identified gap, this study proposes Strategic Educational Presence (SEP) as an extension of existing theoretical frameworks.

SEP reconceptualizes educational presence as:

- Dynamically constructed through interaction modalities
- Mediated by communication strategies
- Shaped by contextual, technological, and institutional conditions

This framework advances current theory by offering a systemic explanation of how interactivity operates across integrated virtual learning environments and responds to the need for a more holistic conceptualization of educational presence.

## 3 Method

This study adopts a mixed-methods approach within a descriptive-exploratory case study design, aimed at analyzing the role of interactivity in virtual learning environments (VLEs) and its relationship with educational presence. Specifically, the research examines how synchronous and asynchronous interaction modalities, communication strategies, and contextual factors shape students' perceptions of educational presence.

### 3.1 Participants

The study was conducted at the Faculty of Social Communication of the University of Guayaquil during the second academic cycle of the 2023–2024 period. A total of 115 undergraduate students participated in the study.

Participants were selected using a non-probabilistic purposive sampling strategy, based on the following inclusion criteria:

- active enrollment in virtual courses within the Communication program,
- regular participation in both synchronous and asynchronous activities, and
- access to the institutional virtual learning platform (Moodle).

Students with incomplete participation records or limited engagement in course activities were excluded from the analysis.

The sample consisted of students aged between 21 and 30 years, including 79 women and 36 men, all enrolled in advanced stages of the program (seventh to ninth semesters). At this stage, students had prior training in communication theory, research methodology, and pre-professional practice, which ensured their familiarity with digital learning environments and interactive communication processes.

The demographic characteristics of the participants are summarized in Table 1.

As shown in Table 1, the sample consists predominantly of female students (68.7%), all within the 21–30 age range and enrolled in advanced semesters of the Social Communication

TABLE 1 Demographic characteristics of participants.

Variable	Category	n	%
Age	21–30 years	115	100
Gender	Female	79	68.7
	Male	36	31.3
Academic level	7th–9th semester	115	100
Field of study	Social communication	115	100

program. Although the sample is context-specific, it is considered appropriate for exploring interaction dynamics within communication-focused academic settings.

### 3.2 Instruments

Data were collected using four complementary instruments, designed to capture both qualitative and quantitative dimensions of interactivity and educational presence.

#### 3.2.1 Interaction analysis matrix

A qualitative interaction analysis matrix was developed based on the conceptualization of e-activities in virtual learning environments proposed by Cabero-Almenara and Palacios-Rodríguez (2021). This framework emphasizes activity-centered instructional design, allowing the classification of interactive tasks according to their pedagogical structure, instructional purpose, and level of student engagement.

##### 3.2.1.1 Teacher self-assessment matrix

A structured matrix was used to evaluate teaching practices within the Moodle platform. This instrument focused on the presence of interactive elements and the manifestation of teaching, cognitive, and social presence within virtual classrooms.

#### 3.2.2 Student survey

A structured survey was administered to assess students' perceptions of interactivity and educational presence. The instrument included items related to:

- Cognitive presence (e.g., reflection, understanding of content)
- Social presence (e.g., interaction with peers)
- Teaching presence (e.g., clarity of instruction, feedback)
- Interaction modalities (synchronous vs. asynchronous participation)

Responses were measured using a three-point Likert scale, ranging from low to high levels of perceived interactivity.

The reliability of the instrument was assessed using Cronbach's alpha ( $\alpha = 0.983$ ), indicating excellent internal consistency (Tavakol and Dennick, 2011). Additionally, content validity was established through expert review, ensuring alignment between items and theoretical constructs.

### 3.3 Observational analysis of virtual classes

A structured observation protocol was applied to **30 recorded synchronous class sessions**, using an adaptation of the framework proposed by Campos et al. (2012). The analysis focused on identifying indicators of cognitive, social, and teaching presence, as well as patterns of interaction between instructors and students.

### 3.4 Operationalization of variables

To ensure analytical clarity, key constructs were operationalized as follows:

- **Interactivity:** Measured through frequency and type of participation in synchronous (e.g., live sessions, chats) and asynchronous activities (e.g., forums, assignments).
- **Cognitive Presence:** Assessed through indicators of reflection, content understanding, and problem-solving.
- **Social Presence:** Evaluated based on peer interaction, communication, and sense of belonging.
- **Teaching Presence:** Measured through instructional design, facilitation, and feedback processes.
- **Technological Access:** Defined by students' access to internet connectivity and digital devices.

### 3.5 Procedure

The research was conducted in three stages:

Stage 1: Theoretical and Instrument Design

A review of existing literature on interactivity and educational presence informed the development of the analytical framework and measurement instruments.

Stage 2: Data Collection

Survey data were collected from 115 students across five virtual classrooms. Participation was voluntary, and informed consent was obtained prior to data collection.

Stage 3: Observational Analysis

A total of 30 recorded synchronous sessions were analyzed to examine interaction patterns and the manifestation of educational presence.

During the study, students engaged in synchronous sessions via Zoom and asynchronous activities through the Moodle platform, structured under the PACIE methodology. Additional tools such as forums, chats, H5P activities, and institutional communication platforms (e.g., Microsoft Teams) were used to support interaction.

### 3.6 Data analysis

Quantitative data were analyzed using descriptive statistics, including frequencies, percentages, means, and standard

deviations, to identify patterns of interaction and perceptions of educational presence. Where applicable, confidence intervals were calculated to strengthen the robustness of the findings.

Qualitative data from observational analysis were examined using a categorical content analysis approach, allowing for the identification of recurring interaction patterns and their relationship with educational presence.

## 4 Results

This section presents the findings derived from the mixed-methods analysis, integrating descriptive statistics and observational data to examine interactivity and educational presence in virtual learning environments (VLEs).

### 4.1 Interactivity in content and activities

The qualitative analysis revealed a predominantly reactive pattern of student participation, characterized by limited initiative, low communicative fluency, and restricted decision-making capacity. Although the instructional design incorporated multiple interactive tools (e.g., forums, chats, collaborative tasks), these were underutilized, suggesting a misalignment between pedagogical design and student engagement.

These findings are summarized in [Table 2](#), which contrasts interactivity in content delivery and activity design.

### 4.2 Educational presence in asynchronous environments

The evaluation of educational presence revealed an uneven distribution across its dimensions, as shown in [Table 3](#).

The results indicate that teaching presence is consistently strong, particularly in clarity and instructional organization. However, cognitive presence is significantly limited, especially in critical engagement indicators such as questioning and application.

Similarly, social presence presents a dual pattern: strong coexistence norms but absence of meaningful peer interaction, reinforcing the idea that interaction is not automatically generated by structural design.

TABLE 2 Interactivity in content and learning activities.

Dimension	Observed characteristics
<i>Interactivity in Content</i> <i>Interactivity in Activities</i>	Students respond reactively to instructions; limited initiative and decision-making; low questioning behavior Emphasis on content delivery rather than dialogic interaction Availability of forums, chats, and collaborative tools Limited student engagement despite access Flexible participation reduces interaction intensity Opportunities for synchronous collaboration exist but are underutilized

### 4.3 Comparison between synchronous and asynchronous interactivity

To address the research questions, interactivity levels and student preferences were compared across modalities (Table 4).

Although interactivity levels are relatively similar across modalities, student preference is significantly higher for synchronous environments (≈20% difference).

This suggests that:

- Interactivity alone does not determine preference
- Perceived immediacy and social presence play a critical role
- This directly supports the argument developed in the discussion regarding the context-dependent nature of interactivity.

The distribution of interactivity levels and student preferences is detailed in Table 5.

Most students reported high levels of interactivity in both modalities, although a stronger preference for synchronous environments is observed.

### 4.4 Observational analysis of synchronous interaction

The analysis of 30 recorded sessions provides further insight into interaction dynamics (Table 6).

The observational data confirms that:

- Teaching presence dominates interaction dynamics, reaching up to 97%
- Cognitive engagement is moderate but uneven
- Social interaction remains limited, particularly in peer collaboration
- These findings reinforce the conclusion that interaction is mediated more by instructional design than by student agency.

### 4.5 Contextual constraints affecting interactivity

Across all data sources, interactivity is consistently influenced by contextual factors, including:

- Connectivity limitations
- Flexible participation policies
- Limited student initiative

These factors contribute to:

- Reduced synchronous engagement

TABLE 3 Educational presence in asynchronous VLEs (Likert scale 0–25).

Dimension	Sub-dimension	Score	Level
Cognitive presence	Student participation	9	Medium
	Questions	0	Low
	Applications	0	Low
Teaching presence	Clarity	18	High
	Participation Incentive	18	High
	Interactivity	14	Medium
Social presence	Student- student interaction	0	Low
	Group coordination	20	High
	Rules of coexistence	23	High

TABLE 4 Interactivity and student preference by modality.

Variable	Level	Synchronous (%)	Asynchronous (%)
Interactivity	High	78.30	74.78
	Medium	18.30	20.00
	Low	3.48	5.22
Student preference	High	75.65	55.65
	Medium	18.26	35.65
	Low	6.09	8.70

TABLE 5 Frequency distribution of interactivity and student preference.

Variable	Category	n	%
Interactivity (Asynchronous)	Low	6	5.22
	Medium	23	20.00
	High	86	74.78
Interactivity (Synchronous)	Low	4	3.48
	Medium	21	18.30
	High	90	78.30
Preference (Asynchronous)	Low	10	8.70
	Medium	41	35.65
	High	64	55.65
	High	64	55.65
Preference (Synchronous)	Low	7	6.09
	Medium	21	18.26
	High	87	75.65

TABLE 6 Observed educational presence in synchronous sessions.

Dimension	Sub-dimension	%
Cognitive presence	Student participation	80
	Questions	50
	Applications	67
Teaching presence	Clarity	90
	Participation incentive	97
	Interactivity	87
Social presence	Student-student interaction	40
	Group coordination	37
	Rules of coexistence	73

- Low peer interaction
- Teacher-centered communication patterns

## 4.6 Integrated results

Taken together, the results indicate that:

- Interactivity is structurally present but functionally limited
- Educational presence is imbalanced, with strong teaching presence but weak cognitive and social engagement
- Synchronous environments are preferred, though not significantly more interactive
- Contextual constraints play a decisive role in shaping interaction patterns

## 4.7 Dendrogram visualisation

The resulting dendrogram (Figure 1) provides a clear hierarchical representation of how the different questions measuring interaction and perception of tool use in the digital learning environment are grouped. The vertical axis (height) reflects the distance at which the groups of questions are combined, indicating the magnitude of the difference between the students' answers. The maximum height of the dendrogram is **0.54**, which implies that, at this level of dissimilarity, all questions merge into a single group. However, when the dendrogram is cut at a height of **0.27** (half distance), four distinct clusters are identified<sup>1</sup>.

In this study, a hierarchical cluster analysis was conducted using students' responses to various tools and interaction dynamics in an online learning environment. The aim was to identify underlying patterns in the perception and use of educational technologies as a function of interaction modality (synchronous vs. asynchronous) and other key factors related to flexible learning. The technique used was hierarchical clustering using the complete linkage method.

The dendrogram cut allowed the identification of four main clusters grouping the questions according to their similarity, which can be interpreted as specific categories reflecting students' perceptions and attitudes towards the learning environment:

### 4.7.1 Cluster 1

**Asynchronous Interaction and Internal Messaging.** This group is composed of variables related to asynchronous communication tools, such as internal messaging and asynchronous interactivity spaces (e.g., forums, shared tasks). Students value these tools for allowing them to exchange information and collaborate with peers and teachers at times that best suit their own schedules, without the need to coincide in real time. This suggests that technologies that allow for time flexibility are central to the positive perception of online learning environments.

### 4.7.2 Cluster 2

**Forum Activities and Collaborative Assignments.** The second cluster is composed of questions related to the use of forums and the performance of collaborative tasks that encourage longer asynchronous interaction. These tools allow students to deepen their understanding of topics over time and contribute to more reflective and sustained learning. The value of forums as a space for consolidation of learning was one of the aspects most highlighted by students.

### 4.7.3 Cluster 3

**Flexibility and Learner Autonomy.** This group includes questions that highlight the role of flexibility and autonomy in the learning process, such as the statement "*I can look repeatedly at the materials*". The ability to repeatedly access educational resources and the ability to manage study time are highly valued by students. Perceived control over the pace of learning is intrinsically related to overall satisfaction in asynchronous learning environments.

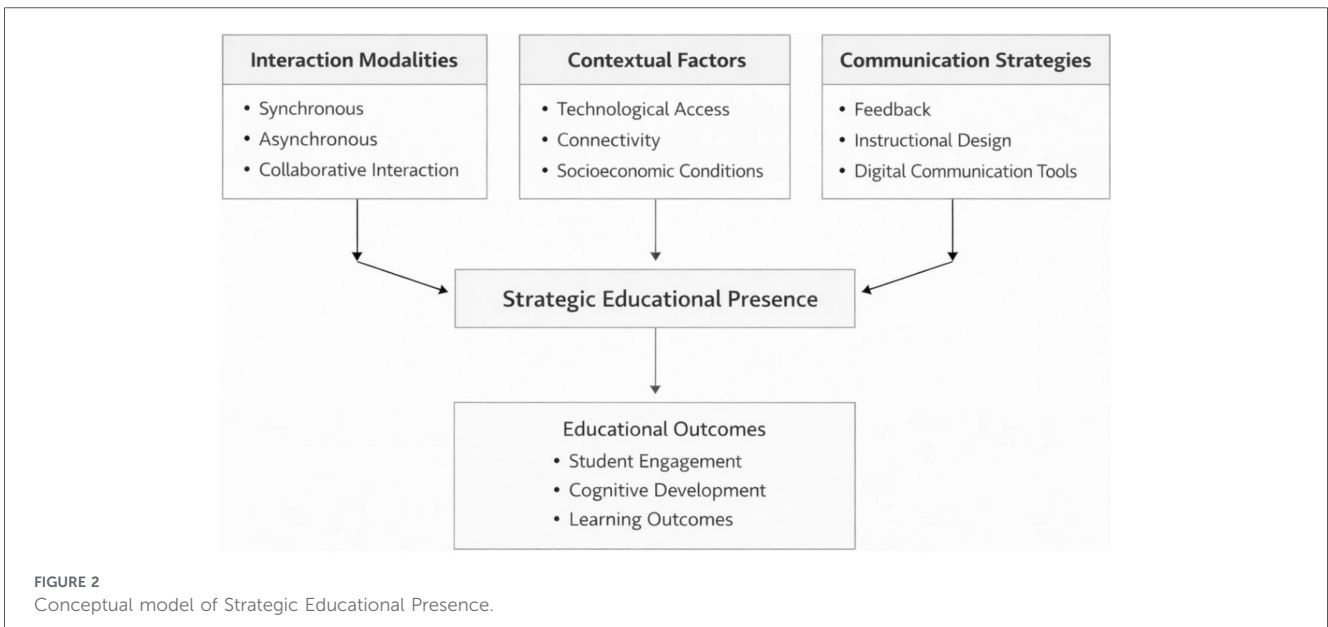
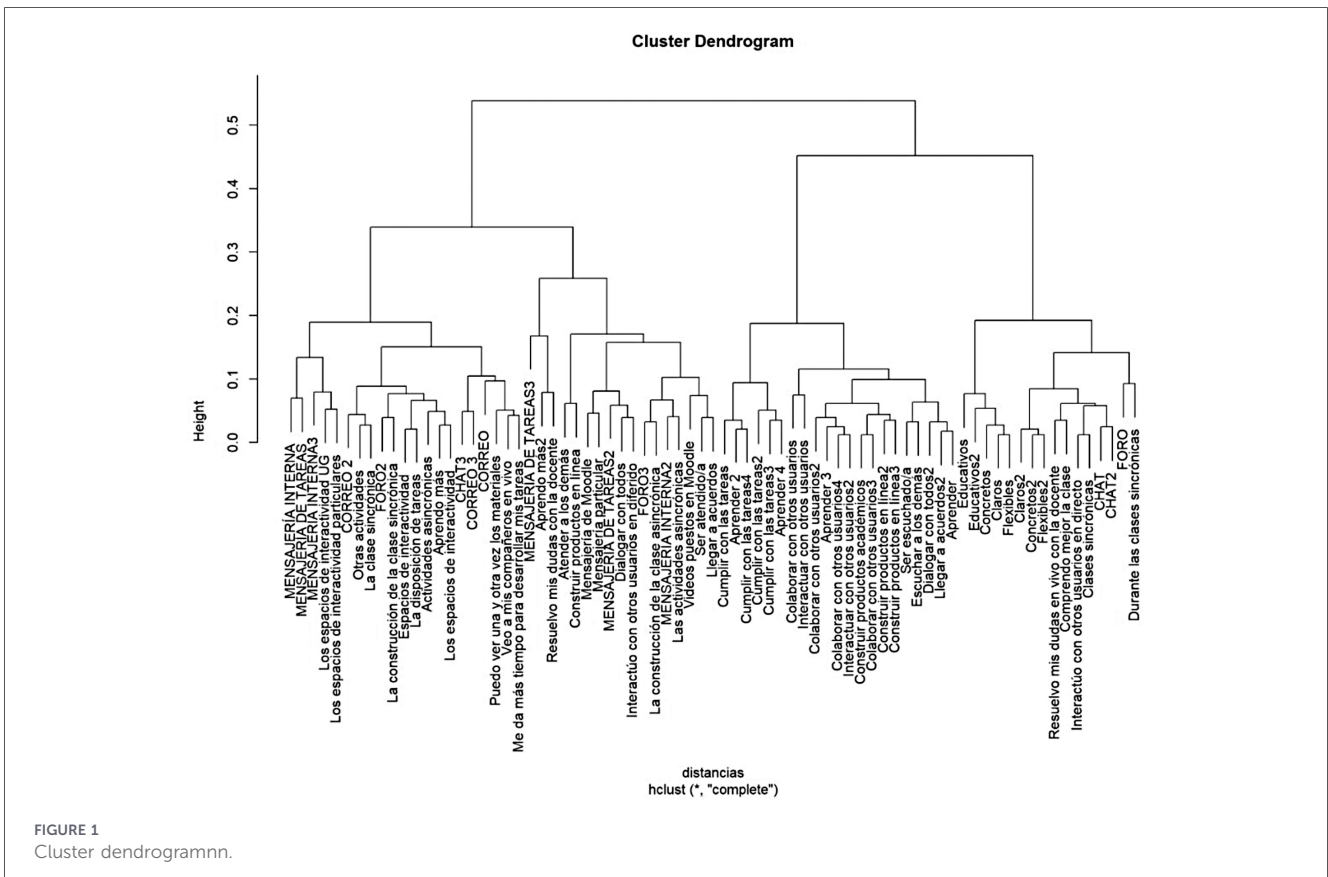
### 4.7.4 Cluster 4

**Synchronous Interaction and Doubt Resolution.** The fourth cluster is composed of questions assessing real-time interaction between students and teachers, such as *I resolve my doubts live with the teacher* and *Interaction with other users during synchronous classes*. This group suggests that students appreciate the opportunity to participate in live classes and receive immediate feedback, which encourages greater participation and a deeper understanding of the topics.

The cluster analysis reveals important patterns in students' perceptions of the use of educational tools in digital environments. The results indicate that students perceive synchronous and asynchronous modes of interaction differently, and value aspects such as flexibility, the ability to review materials at their own pace, and the possibility to interact in real time when needed. Asynchronous tools such as forums and internal messaging stand out as essential components for learners who prioritize time flexibility. In contrast, synchronous tools, such as live lectures and chats, are grouped together with question-answering activities, suggesting a greater preference for immediate feedback in certain educational contexts. This dichotomy between synchronicity and synchronicity is a key finding for the pedagogical design of online courses, as it suggests that students value different aspects of these modalities according to their needs and learning styles.

The results suggest that a blended pedagogical strategy, combining both synchronous and asynchronous interaction tools (Figure 2), may be particularly effective in maximizing student satisfaction and performance in digital learning environments. Asynchronous flexibility allows learners to manage their time and delve into materials at their own pace, while synchronous interaction provides valuable space for immediate question resolution and direct interaction with the instructor and other learners. This hierarchical cluster analysis provides crucial information about the structure of learners' preferences regarding interaction tools and dynamics in online learning environments. The identification of four main clusters underlines the need to offer a variety of interaction

<sup>1</sup>The full cluster dendrogram analysis is available at <https://bit.ly/3MBqaH1>



modalities to suit different learner needs. These findings can guide the design of future educational programs and digital platforms, optimize the user experience and facilitate more effective and personalized learning. The observed differences in synchronous and asynchronous interaction preferences highlight the importance of balancing both modalities to foster inclusive and flexible learning, thereby improving student satisfaction and academic outcomes.

## 5 Discussion

The findings of this study contribute to a more nuanced understanding of interactivity in virtual learning environments by moving beyond deterministic interpretations and situating interaction within a context-dependent and strategically mediated framework. Rather than confirming that interactivity

inherently improves learning outcomes, the results indicate that its effectiveness depends on how interaction modalities are configured, the communication strategies employed, and the contextual conditions in which they operate.

The results reveal that synchronous interaction tends to strengthen teaching and social presence due to its immediacy and capacity for real-time feedback. This aligns with international research emphasizing the role of immediacy in fostering engagement and instructional clarity. However, the findings also demonstrate that asynchronous interaction plays a crucial role in sustaining cognitive presence by enabling reflection, self-paced learning, and deeper content processing.

Importantly, these results challenge reductionist perspectives that privilege one modality over the other. Instead, they suggest that interactivity should be understood as an ecosystem of complementary processes, where synchronous and asynchronous dynamics jointly contribute to the construction of educational presence. This interpretation responds directly to the need, identified in recent literature, to move from modality-centered analyses toward integrated models of interaction.

## 5.1 Theoretical contribution: toward strategic educational presence

A central contribution of this study lies in advancing the concept of Strategic Educational Presence as an extension of the Community of Inquiry (CoI) framework. While the CoI model has traditionally conceptualized cognitive, social, and teaching presence as interdependent dimensions, its empirical application has often remained descriptive and insufficiently connected to the design of interaction processes.

The present findings suggest that these presences are not only coexisting dimensions but are actively configured through intentional communication strategies and interaction design decisions. From this perspective, educational presence emerges as a dynamic and constructed phenomenon, shaped by the alignment between pedagogical objectives, communication practices, and interaction modalities.

This reconceptualization contributes to ongoing international debates regarding the evolution of the CoI framework by incorporating a strategic and communicational layer, thereby addressing the limitations identified in prior studies that call for more integrative and analytically robust approaches.

## 5.2 Interactivity under constraint: the role of socioeconomic and technological factors

A key finding of this study is the significant influence of technological access and socioeconomic conditions on interaction patterns. Students with limited connectivity or restricted access to digital devices showed reduced participation in synchronous activities, which in turn affected their perception of teaching and social presence.

This finding reinforces emerging evidence from global research indicating that digital inequality is a structural factor shaping online learning experiences. However, this study

advances this discussion by demonstrating that such inequalities are not merely external constraints but constitutive elements of interactivity itself. In other words, the quality and intensity of interaction cannot be fully understood without considering the material conditions that enable or restrict participation.

This perspective contributes to a more critical understanding of interactivity, particularly in contexts where access to technology is uneven, and highlights the need for context-sensitive models of virtual education.

## 5.3 Implications for instructional design and institutional policy

The findings have several implications for both instructional practice and institutional decision-making. At the pedagogical level, the results suggest that effective virtual learning environments require a deliberate and balanced integration of synchronous and asynchronous activities, rather than reliance on a single dominant modality.

Specifically:

- Synchronous interaction should be strategically employed to enhance immediacy, feedback, and social cohesion.
- Asynchronous interaction should be designed to support reflection, critical thinking, and sustained engagement.
- Communication strategies should be explicitly aligned with learning objectives and adapted to students' contextual realities.

At the institutional level, the findings highlight the importance of investing in technological infrastructure, digital accessibility, and faculty training, as these factors directly influence the effectiveness of interaction processes. Addressing digital inequalities is therefore not only a matter of access but a prerequisite for ensuring equitable learning experiences.

## 5.4 Strategic educational presence: a conceptual model

The proposed model conceptualizes Strategic Educational Presence as the central construct that integrates interaction modalities, communication strategies, and contextual factors within virtual learning environments. Rather than emerging solely from the existence of interactive tools or instructional design, educational presence is understood as a strategically mediated process shaped by the alignment of these dimensions.

Interaction modalities, particularly the coexistence of synchronous and asynchronous environments, provide structural conditions for engagement but do not inherently guarantee effective interaction. Their impact depends on how communication strategies—such as feedback mechanisms, instructional clarity, and interaction management—are implemented to facilitate meaningful exchanges between participants. At the same time, contextual factors, including technological access, connectivity conditions, and institutional support, play a decisive role in enabling or constraining these processes.

The model further suggests that the effectiveness of educational presence is reflected in key educational outcomes, including student engagement, cognitive development, and perceived learning performance. In this regard, the findings indicate that even when interactivity is structurally available, its impact remains limited if it is not supported by favorable contextual conditions and strategically designed communication processes.

This conceptualization extends the Community of Inquiry framework by incorporating a strategic and context-sensitive perspective, emphasizing that educational presence is not only an emergent property of interaction but also a deliberately structured and mediated construct. Consequently, the model provides a theoretical basis for understanding how interaction dynamics can be optimized in virtual learning environments, particularly in contexts characterized by technological and socioeconomic constraints.

## 5.5 Limitations and scope of interpretation

The interpretation of these findings must be considered considering several limitations. First, the study is based on a single academic program within a specific institutional context, which limits the generalizability of the results. Second, the reliance on self-reported data introduces the possibility of response bias, particularly in the measurement of perceived educational presence. Third, the study does not fully control additional variables such as prior digital competence or individual learning preferences, which may influence interaction patterns.

These limitations suggest that the findings should be understood as contextually grounded insights, contributing to theory-building rather than providing universally generalized conclusions. At the same time, they reinforce the need for more robust and diversified research designs in future studies.

## 5.6 Future research directions

Building on these findings, future research should aim to further develop and validate the concept of Strategic Educational Presence across different contexts. In particular:

- Comparative studies across disciplines and institutions would enhance external validity.
- Longitudinal research could examine how interaction and educational presence evolve over time.

## 6 Conclusion

This study examined the role of interactivity in virtual learning environments through the lens of educational presence, with a particular focus on the interplay between synchronous and asynchronous modalities, communication strategies, and contextual conditions. The findings suggest that interactivity does not operate as an inherently effective mechanism, but rather as a context-dependent process whose impact is mediated by pedagogical design, communication practices, and structural factors.

One of the central conclusions is that synchronous and asynchronous interactions should not be understood as competing modalities, but as complementary dimensions that jointly contribute to the construction of educational presence. While synchronous interaction enhances immediacy, feedback, and social connection, asynchronous interaction supports reflection, self-regulation, and deeper cognitive engagement. Their combined and intentional use appears to be a key factor in fostering meaningful learning experiences.

From a theoretical perspective, this study contributes to the ongoing development of the Community of Inquiry framework by proposing the concept of Strategic Educational Presence. This notion emphasizes that educational presence is not merely an emergent property of interaction, but a deliberately constructed phenomenon shaped by the alignment between instructional design, communication strategies, and interaction modalities. In this sense, the study extends existing models by integrating a strategic and communicational dimension into the analysis of virtual learning environments.

At the same time, the findings highlight the importance of considering technological and socioeconomic constraints as integral components of interactivity, rather than as external variables. Differences in access to connectivity and digital resources were shown to influence participation patterns and perceptions of presence, underscoring the need for context-sensitive approaches to online education.

In practical terms, the study suggests that effective instructional design in virtual environments requires a balanced and intentional integration of synchronous and asynchronous activities, supported by clear communication strategies and adapted to students' contextual realities. Additionally, institutional efforts to improve technological infrastructure and digital competencies are essential to ensure equitable participation and enhance the effectiveness of interactive processes.

These conclusions should be interpreted considering the study's limitations, including its focus on a single institutional context, the use of self-reported data, and the absence of control over certain external variables. Consequently, the findings are best understood as contextually grounded contributions that inform theory development rather than universally generalized claims.

Future research should continue to explore the applicability of Strategic Educational Presence across different disciplines and educational settings, incorporating longitudinal designs and more advanced analytical approaches to further examine the relationships between interactivity, communication, and learning outcomes.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#), further inquiries can be directed to the corresponding author.

## Author contributions

LM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software,

Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. EG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. YR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. FV: Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft. JF: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declared that financial support was received for this work and/or its publication. Funding for this publication was provided by the Universidad Agraria del Ecuador, which covered the Article Processing Charges (APC).

## Acknowledgments

The authors wish to thank the Academic “Alma Mater”.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2026.1771906/full#supplementary-material>

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