Exploring the Community of Inquiry in Online Computing Education: Student Perceptions and Opportunities for Generative AI

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Abstract

Online learning increasingly offers flexibility and accessibility to students in computing education. However, it also presents drawbacks such as reduced engagement, lack of real-time support, and limited personal interaction. These challenges are particularly consequential in software engineering education, where collaboration, communication, and teamwork are central to both educational and professional practice. Recent advancements in generative artificial intelligence (GenAI) have the potential to revolutionize online learning experiences, necessitating research to understand students' perceptions of online computing courses and how GenAI could support them. Grounded in the Community of Inquiry (CoI) framework, we explore how GenAI could support online learning experiences. We distributed an online survey, receiving responses from 86 students with experience taking a variety of online computing courses. Our results show that students perceive traditional online courses as lacking support for CoI elements and factors, and they believe GenAI can enhance the learning experience through personalized and timely feedback, task decomposition, reduced social pressure, and responsive, nonjudgmental instructional support. Yet, concerns persist, including AI-generated misinformation and hallucinations in the responses, and the challenge of building social connections and group cohesion with GenAI's interaction style. Based on our findings, we provide implications and future research directions for leveraging AI to enhance students' experiences in online learning environments to support effective computing education.

CCS Concepts

• **Applied computing → E-learning**; *Distance learning*.

Keywords

Generative AI, Online Learning, Community of Inquiry

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1 Introduction

Online learning transcends traditional education boundaries in computing education, offering learners access to knowledge and educational resources through the Internet. This mode of learning is gaining traction among diverse populations seeking flexible and accessible education options [25]. However, online learning can incorporate unique challenges for students compared to in-person settings, including a lack of active learning and effective communication [66]. In online software engineering (SE) education, these challenges can result in students struggling with collaborative software development tasks, negotiating design decisions, building shared understanding, and receiving timely, context-aware feedback [17, 48].

Prior work suggests online learning lacks engagement for students [8, 46], which is essential for training future software professionals [49] and broadening participation in computing education [36]. To characterize engaging educational experiences, Garrison proposed the Community of Inquiry (CoI) framework [30], indicating that cognitive presence, social presence, and teaching presence are key elements contributing to a satisfying and effective learning environment. However, existing work shows online learning often falls short with regard to CoI framework elements [62].

Recent developments in generative artificial intelligence (GenAI) present an opportunity to revolutionize online learning. For example, GenAI can create course content [21], simulate social interactions [57], and even serve as a teaching assistant or instructor [45]. However, the integration of such technologies raises important questions about their impact on students' learning experiences, underscoring the need to gather student insights that can guide the develop innovative methods and systems to support and enhance online learning experiences in computing education.

In SE education, the Software Engineering Body of Knowledge (SWEBOK 4.0) [75] defines a set of knowledge areas that students are expected to learn, including technical areas, professional practice areas, and the foundations knowledge area. In this study, we explore students' perceptions of online SE and computer science (CS) courses spanning different SWEBOK knowledge areas and how GenAI could influence learning through the lens of the CoI framework [30]. We seek to answer the following research questions:

RQ1: What are students' perceptions of cognitive, social, and teaching presence in online computing education?

RQ2: What are students' perceptions on the use of generative AI to support cognitive, social, and teaching presence in online computing education?

To answer these questions, we conducted a survey to gain insights from students. We received responses from 86 students with experience taking online computing courses across levels and topics. Our findings show that in the current online courses, cognitive and teaching presences were well-supported, but students perceive social presence as less supported, especially for factors of emotional expression and group cohesion. Students expressed interest in using GenAI to enhance cognitive presence and value GenAI's ability for providing real-time feedback, breaking down complex tasks, and supporting adaptive learning pathways. However, concerns about misinformation and hallucinations remain prevalent. Students noted GenAI as helpful for reducing social pressure and encouraging open communication, but were less convinced of about its ability to enhance social presence, citing its limited emotional connection, absence of non-verbal cues, and limited ability to simulate human-like interaction. Students appreciated GenAI's potential to support teaching presence by providing clear, responsive instructional support, and the nonjudgmental feedback could reduce anxiety for students who may hesitate to ask questions to instructors. Based on our findings, we provide implications for improving CoI elements and factors in online learning and integrating GenAI to enhance students' learning experiences.

2 Background and Related Work

2.1 Community of Inquiry

Garrison [30] introduced the CoI framework, encompassing cognitive, social, and teaching presences. This framework underscores fundamental components for facilitating meaningful online educational experiences. The emphasis on creating an online learning environment that supports not only the cognitive aspect of learning but also the social and teaching interactions aligns with subsequent research highlighting the importance of a comprehensive educational experience in virtual settings. The proposed CoI model has served as a cornerstone for further empirical studies, aiming to enhance the effectiveness of online learning platforms by fostering an engaging, interactive, and reflective learning environment. The work suggests that through strategic facilitation and the leveraging of technology, online education can achieve levels of critical inquiry and student engagement traditionally associated with face-to-face learning environments. Prior work has also explored the existence of CoI in a graduate-level educational technology online course focused on the elements, and found that CoI effectively fosters a sense of community in online graduate-level courses, with teaching presence being the strongest element, while some students struggled with expressing disagreement and collaborative assignments [42]. Rahman's work demonstrates how requirements engineering can be leveraged to elicit and formalize social presence requirements in e-learning systems, showing that in SE contexts, social interaction must be treated as a deliberate design concern [2]. In our work, we adopt the definition of different elements and factors in CoI introduced by Garrison, as defined in Table 1, and use them to help us evaluate student perceptions of online computing courses and how GenAI could affect them.

2.2 Online Learning

Online learning in computing education has become increasingly prevalent, driven by technological advancements and global events such as the COVID-19 pandemic [25]. It typically employs two primary formats: synchronous and asynchronous learning, each designed to accommodate different learning styles and schedules. Synchronous learning enables real-time interpersonal communication similar to the in-person format, but it leverages digital platforms and technologies to facilitate interactions. Stefanile found that online course enrollment grew significantly in recent years with the adoption of tools like Zoom[1] and Skype[2] to improve students' engagement [70]. For example, Bridson found that round-the-clock support on Discord was associated with improved responsiveness and perceived availability during a remote SE course [9]. The limitations of this format include technical and logistical complexities in delivering course contents [25, 60], and difficulty in monitoring student engagement [5, 78]. Asynchronous learning offers flexibility by allowing students to engage with course materials at their own pace. This format typically includes pre-recorded video lectures, digital textbooks, and self-paced coding exercises. Students can access these resources and complete assignments within specified deadlines, accommodating diverse schedules and learning speeds. However, asynchronous learning but lacks immediate feedback and social interaction potentially leading to feelings of isolation among students, and requires strong self-regulation skills among students [38, 59]. Large-scale evidence from a project-based SE course showed persistent technical challenges and time-management problems after the switch online, even as collaboration tools eased organization and communication [71].

Existing works have explored factors affecting and ways to improve student learning experience in online learning [51]. Cowit found that instructor support, use of humor and peer interactions significantly influence students' sense of belonging in virtual learning environments [18]. Fong explored collaborative strategies to enhance the sense of belonging and found that peer interactions and collaborative activities can improve students' sense of belonging and engagement in online courses [26]. For this project, we investigate learner-centered perceptions with the support of technologies for delivering course content in synchronous and asynchronous learning environments, and the opportunities for GenAI with regard to the CoI framework.

2.3 AI in Education

The integration of AI in education has gained significant attention in recent years. With the rapid advancement of GenAI technologies, researchers have begun exploring their potential to enhance various aspects of the student's learning experience in computing education [37, 41]. GenAI has been integrated in computing courses for supporting auto-grading [44, 64], generating course content [11, 23, 27, 69, 84], and providing personalized learning experiences [39]. Also, the GenAI-powered agents could serve as co-learners that emerged as a potential improvement in social presence in online learning [13, 24]. Recent work has also explored the potential of using GenAI-powered agents as AI instructors and teaching

[1]https://www.zoom.com/
[2]https://www.skype.com/en/, now defunct

Table 1: Overview of the CoI Framework: Elements, Definitions, and Key Factors

Elements	Definition	Factors
Cognitive Presence	The extent to which learners are able to construct and confirm meaning through sustained reflection and discourse.	Triggering Event Exploration Integration Resolution
Social Presence	The ability of participants in the Community of Inquiry to project themselves socially and emotionally, as well as to perceive other participants as real people.	Affective Expression Open Communication Group Cohesion
Teaching Presence	The selection, organization, and primary presentation of course content as well as the design and development of learning activities and assessment.	Instructional Management Building Understanding Direct Instruction

assistants (TAs), to improve the teaching presence in CoI [22, 45, 77]. For SE education, Frankford conducted an exploratory study integrating GPT-3.5 as an AI-Tutor within an automated programming assessment system, revealing both the potential for timely, scalable feedback and the challenges of generic responses and limited interactivity in student learning experiences [28]. Studies have also explored student perceptions of AI in educational contexts [7, 12, 80]. For instance, Skripchuk [67] found that students' intention to use GenAI for programming help is primarily shaped by their perceived usefulness and trust in the tool, highlighting the importance of aligning AI support with learners' expectations. In broader trends and context, Sengul's article provides a comprehensive review of how conversational agents and GenAI are impacting SE education, pointing out a widening adoption gap between industry and academia and calling for research on student experience, pedagogical design, and alignment with professional practice [65]. While these studies show promising results, there are still questions about how students perceive GenAI could support their learning in an online learning context. Our study builds upon the existing research by exploring student perceptions of using GenAI through the lens of the CoI framework, providing insights into how students view the potential integration of AI in their online learning experiences.

3 Methodology

3.1 Participant Recruitment

To understand students' perception of existing online computing courses with the CoI framework, and students' perception of using GenAI to support the elements and factors in CoI, we conducted a survey with undergraduate and graduate students who have experience with taking online computing courses. To answer our research questions, we distributed the survey via online forums for different levels and topics of computing related courses offered in our institution, our university's mailing list, social media platforms, including Reddit[3], and the research survey distribution platform Cloud Research[4] to recruit a diverse sample of participants. To ensure data quality, the survey included an attention check question and a memory check question. Responses that failed either check were excluded from the analysis. The survey took an average of 16 minutes to complete, and participants were compensated for their time and effort. The study was approved by the Institutional Review Board (IRB) at our institution. A total of 108 responses were collected. To ensure participants had relevant experience, a screening question was used to assess whether they had previously taken any online computing courses. This screening led to the exclusion of 22 participants, resulting in a final sample of 86 responses included in the analysis.

3.2 Survey Design

The survey contained a total of 40 questions divided into four blocks. To ensure students' understanding of the CoI framework, the description of the concepts was introduced to students in the survey heading, and the definitions of its elements and factors were incorporated into the questions and options. Block 1 included screening questions to identify students with experience in online computing courses, with questions to gather demographic information. For answering the remaining questions, participants were asked to reflect on their current or most recent completed online computing course, and the information related to the course was collected by questions in Block 2. Block 3 contained questions to collect students' perceptions of existing online computing courses with regard to CoI. Participants were primed with a brief overview of the CoI framework. We used 5-point Likert scale questions—1 (Strongly Disagree) to 5 (Strongly Agree)—to collect participants' opinions on how existing online computing courses support factors in cognitive presence, social presence, and teaching presence. In addition, for each factor, we asked participants whether the online course provided sufficient support compared to in-person courses.

We also asked an optional follow-up open-ended question about why participants gave their ratings after each Likert scale question. Block 4 contained questions to gather student perceptions of using GenAI in online courses. We first asked about participants' previous experience with AI and their general perception of working with AI. Then, we asked participants to reflect on the integration of AI in supporting the cognitive, social, and teaching presence of online learning, and answer the Likert Scale questions related to how they perceived GenAI could support each CoI element. To standardize knowledge across participants, we provided high-level examples of

[3]https://www.reddit.com/
[4]https://www.cloudresearch.com/

how GenAI could be used for the CoI elements such as generating course materials, serving as additional interactive AI co-learners, and additional AI instructors and TAs. The survey is made available online.[5]

3.3 Data Analysis

To analyze the collected data, a multi-faceted approach was employed, catering to the different types of questions used in the survey. For multiple-choice questions, we used descriptive statistics, including frequency counts and percentages, to summarize the distribution of responses. For Likert scale questions, measures of mean were calculated to capture the central responses. Additionally, we performed a Mann-Whitney U test to compare Likert responses regarding student perceptions of CoI elements between synchronous and asynchronous courses, with statistical significance assessed at $p < 0.05$. For open-ended questions, we use open coding thematic analysis to derive themes from participant responses [76]. Two researchers independently analyzed statements to extract key themes, patterns and illustrative quotes from open-ended responses. In the results section, participant responses are labeled with unique identifiers (e.g., P1) to denote individual participants while maintaining anonymity and coded themes are depicted in bold.

3.4 Participants

Survey participants were university students who have experience taking online computing courses. The participants varied in gender, with a distribution of 60.47% male (n = 52), 37.21% female (n = 32), 1.16% (n = 1) non-binary and 1.16% (n = 1) preferred not to say. We also received responses from participants across various age groups, with an age distribution of 18.6% (n = 16) participants aged 18-20, 46.51% (n = 40) aged 21-25, 24.42% (n = 21) aged 26-30, 5.81% (n = 5) aged 31-35, 1.16% (n = 1) over 35, and 3.49% (n = 3) who preferred not to say. The participants had a student status distribution of 62.79% (n = 54) undergraduate students, and 37.21% (n = 32) graduate students. On average, participants reported taking approximately six online computing courses.

Participants were asked to reflect on one current or recent online computing course they have taken. The selected courses spanned different levels, including 40.7% (n = 35) introductory, 44.19% (n = 38) intermediate, and 15.12% (n = 13) advanced, and spanned a wide variety of topics—all spanning SWEBOK knowledge areas (i.e., Software Design and Engineering, Data Structures, Introduction to Java/C Programming, Theory and algorithms, Professionalism in Computing, etc.). In addition, the majority (81.4%, n = 70) of courses were programming courses involving coding. 54.64% (n = 47) of the courses were delivered in an asynchronous format, while the other 45.35% (n = 39) were synchronous. Finally, we observed that participants had varied experiences with GenAI. 10.47% (n = 9) of participants had no experience, 60.47% (n = 52) had some experience, and 29.06% (n = 25) had extensive experience with GenAI, indicating the majority of participants were familiar with GenAI tools and their capabilities.

[5]Anonymized Survey Questions: https://anonymous.4open.science/r/CoIOnlineLearningStudy-CB52

4 Results

4.1 RQ1: CoI in Online Computing Courses

Our results for student perceptions of CoI in existing online computing courses are displayed in Figure 1. Participants rated the extent to which they agreed elements within the CoI framework were supported. The results on support for cognitive presence, social presence, and teaching presence received average scores of 3.75, 2.99, and 3.74 on a 5-point Likert Scale. Compared to cognitive presence and teaching presence, social presence received the lowest score—indicating students feel social presence is not sufficiently supported in existing formats for online computing courses. Based on the Mann-Whitney U test, no significant differences were observed between synchronous (n = 39) and asynchronous (n = 47) course formats in students' perceptions of cognitive presence (U = 706.5, p = 0.0662), social presence (U = 841.5, p = 0.5158), or teaching presence (U = 854.5, p = 0.5883). We provide insights from participants on each CoI element below. From the optional open-ended questions asking why students give the rating to each factor, we identified opinions on how students think about existing CS online courses supporting each CoI element.

4.1.1 Cognitive Presence. Cognitive presence had the highest perceived support for online computing courses. Participants noted courses **effectively sparked interest and curiosity**, making it more engaging (P76, P60, P15), **provide flexibility in the learning environment** (P20, P65), and **different types of materials and assignments could help in understanding the material** (P12, P14, P17). However, some participants indicated the courses **offer limited opportunities for engaging in discourse or posing questions** (P6, P28, P81), **need better connections between topics** (P14, P42, P59, P79), and **need more comprehensive feedback and follow-up discussions** (P14, P11, P54). For instance, P79 indicates the concerns about off-topic discussion forum in an asynchronous course, states:

> *I think that our student discussions held on a chat forum were not useful to me very much at all. I think it's mainly because of how my teacher went about it. The discussions were not related much at all to the actual topics we learned in class and from the classwork. (P79)*

For factors in cognitive presence, triggering event, exploration, integration, and resolution received average scores of 3.65, 3.72, 3.87, and 3.78 respectively. Further, as shown in Table 2, the majority of students reported similar cognitive engagement across the four factors for in-person and online courses: 51.16% in Triggering Events, 54.65% in Exploration, 62.79% in Integration, and 72.09% in Resolution. These findings suggest students perceive strong support for cognitive presence in online computing learning, with the highest level during the integration phase. We further investigate how these factors are applied in current online computing courses.

Triggering Event. A triggering event involves students recognizing a problem that creates an inquiry. In online computing courses, we found that triggering events typically occur when working on individual assignments (n = 63). Other common scenarios include working on group assignments or projects (n = 36) and studying independently on external resources (n = 35). Exploring lectures or

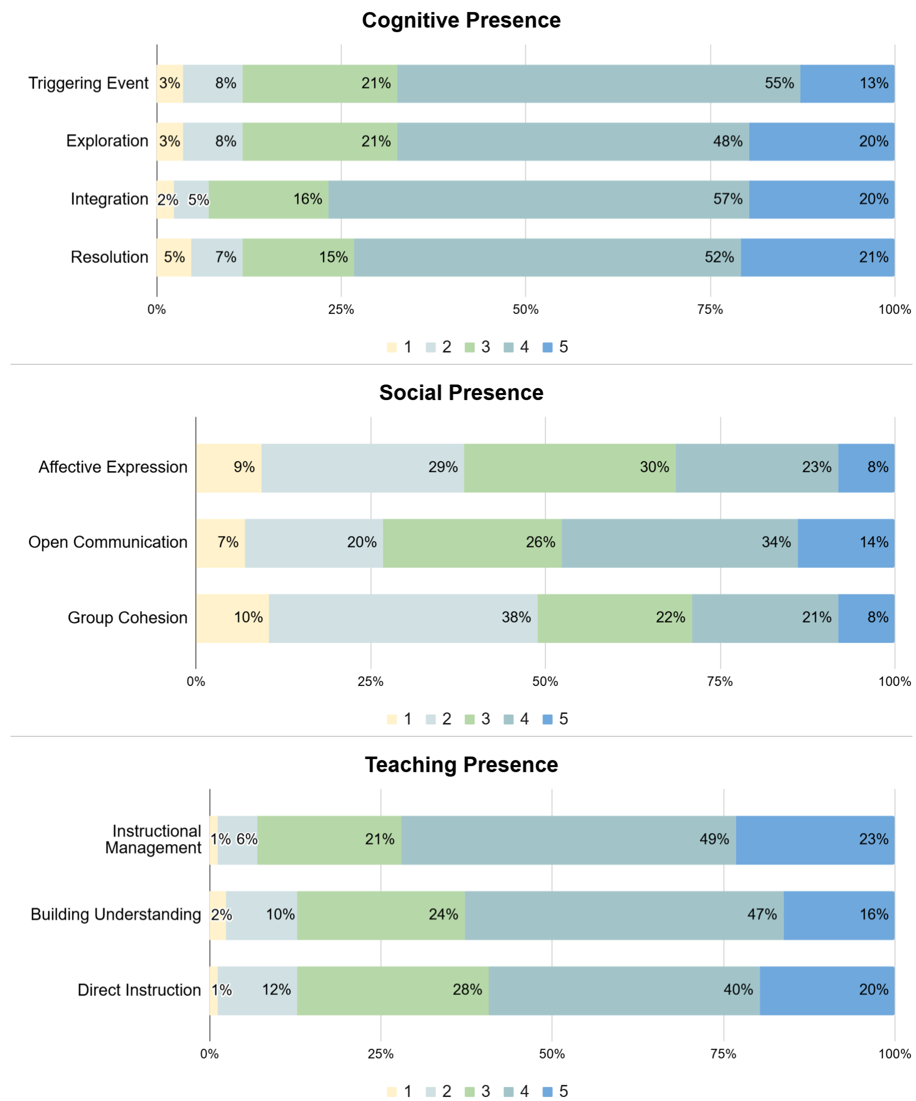

Figure 1: Distribution of participants' perceived Cognitive presence, Social Presence and Teaching Presence with related factors in Online computing Courses based on a 5-Point Likert Scale (1 indicates Strongly Disagree and 5 indicates Strongly Agree)

slides (13.04%, n = 33) and preparing for and taking exams (n = 31) also prompt further inquiries for students.

Exploration. To exchange and search for further information after an inquiry, students primarily turn to external online resources (n = 71), course materials (n = 55), tutorial videos (n = 50), discussions with classmates (n = 33), and instructor or TA office hours (n = 32). Notably, more students perceived Exploration improved in online settings (23.26%) than those who noted a decline (22.09%), suggesting online may facilitate better support in helping students understand and explore course concepts.

Integration. Integration refers to connecting different ideas into a coherent understanding. Students identified working on individual assignments (n = 49) as the most effective activity for integration. Exploring lectures or slides and studying independently with external resources are also key, each selected by 44 students. Participating in class activities (n = 35) and working on group assignments (n = 32) are also seen as beneficial.

Resolution. The final cognitive presence factor involves resolving the initial inquiry. This typically occurs when students work on individual assignments (n = 63), work on group projects (n = 36), use external resources (n = 35), and explore lecture content (n = 33).

4.1.2 *Social Presence.*

Social presence received the lowest CoI scores. For positives, respondes noted online computing courses have **less social pressure and judgmental attitudes** (P5, P17, P20) and **activities building a sense of community among students** (P11, P14, P63, P65). For instance, P6 appreciates the flexibility in asking questions in synchronous online course, saying:

Table 2: Comparison of CoI Factors Between Online and In-Person Courses

CoI Presence	Factor	Similar to In-Person Courses(%)	Worse than In-Person Courses(%)	Better than In-Person Courses(%)
Cognitive	Triggering Event	51.16	29.07	19.77
	Exploration	54.65	22.09	23.26
	Integration	62.79	22.09	15.12
	Resolution	72.09	15.12	12.79
Social	Affective Expression	31.4	60.47	8.14
	Open Communication	44.19	41.86	13.95
	Group Cohesion	37.21	56.98	5.81
Teaching	Instructional Management	61.63	23.26	15.12
	Building Understanding	54.65	32.56	12.79
	Direct Instruction	53.49	23.26	23.26

> *When I don't understand the material during class, I can send a chat or private message to the instructor for an explanation. However, during in-person classes, I have to wait until the class ends to ask the instructor because I feel a bit shy about asking questions in front of everyone. (P6)*

However, participants faced challenges such as **more distracted with less interaction** (P1, P2, P42, P53), **limited opportunities for informal socialization** (P14, P16, P79, P81), and **hard time connecting with group members**" (P10, P15, P57, P61). For example, P3 expressed the lack of a sense of community, stated that "*I wouldn't say there was a big sense of community or belonging though, it's an online class where you don't interact with each other much*". P79 found it hard to connect with peers, saying "*The only way in this class to discuss topics was through our discussion posts, but they weren't enough to foster actual genuine discussion and overall, it led to a lack of connection between me and my peers*". Also, there's lack of opportunity for socializing, such as P82 states "*There were no real opportunities to socialize with the whole class freely except for discussion boards. However, these discussion boards were really only about answering prompts that didn't foster continuous conversation*".

For factors of social presence, we found Affective Expression, Open Communication, and Group Cohesion received average Likert scores of 2.92, 3.28, and 2.78 respectively. This indicates students found online courses more effective for facilitating the dialogue and exchanging ideas in comparison to conveying emotions and forming strong, cohesive groups. We also found reduced perceptions of social presence factors in online computing courses compared to the in-person courses (see Table 2).

Affective Expression. Affective expression refers to the capacity to display emotions. Participants expressed major concerns with this factor in online computing courses, with 60.47% of students reporting a decline in their ability to express emotions effectively online, and only 8.14% seeing an improvement. This suggests online platforms might inhibit the emotional interactions that occur in face-to-face settings.

Group Cohesion. Group cohesion involves activities that build and sustain community in an educational experience. Participants similarly exhibited difficulties with group cohesion, with 56.98% of students feeling that the online format hindered their ability to form cohesive relationships, pointing to a substantial impact on the quality of group dynamics in digital classrooms.

Open Communication. Open communication is defined as reciprocal and respectful exchanges between students. Compared to the other factors, open communication received varied responses from participants: 44.19% ($n = 38$) perceived it is about the same compared to the in-person course, 41.86% ($n - 36$) felt it was worse, and 13.95% ($n = 12$) reported an enhancement.

4.1.3 Teaching Presence. Most participants agreed teaching presence is often supported in current online courses. Participants responded that **instructors make the course well-structured with clear objective** (P11, P14) and **instructors provide accessible and responsive instruction** (P5, P17, P20). However, other participants indicated challenges with teaching presence in online computing courses, such as one participant responding they **sometimes needed more examples/support from the instructor** (P24, P42, P53). P12 found the online course lack of direct instruction, stated that"*The only issue was not having timely responses from the instructor. Since it was an asynchronous course, we did not have time to engage with the instructor and ask questions directly*". Also, P29 indicates that implementing active learning strategies such as asking questions in instructional settings can be challenging, stating "*What usually happens according to my experience is the instructor keeps asking 'Any volunteer?' And no one answers, the online course space suddenly became space - no sound conduction!*".

For factors in teaching presence, the results show that Instructional Management, Building Understanding, and Direct Instruction received average scores of 3.87, 3.64, and 3.65, respectively. These scores indicate a generally high level of effectiveness in the online course for supporting teaching presence. Table 2 shows the results of teaching presence in online computing courses compared to in-person formats, the statistics reveal diverse perceptions.

Instructional Management. Instructional Management addresses structural concerns with classes, such as course curricula, assessments, planning, etc. This factor is seen as largely consistent by

61.63% (n = 53) of students, though 23.26% (n = 20) perceived a decline and 15.12% (n = 13) noted improvements.

Building Understanding. This factor refers to the ability of instructors to support knowledge acquisition for students. Participants' perception of building understanding showed 54.65% (n = 47) reporting no change; however, 32.56% (n = 28) felt a decrease in effectiveness, with only 12.79% (n = 11) saw an enhancement.

Direct Instruction. Direct instruction consists of the efficacy of the educational process, such as instructors' ability to facilitate reflection and provide timely and effective feedback. For this factor, students had split perceptions: 53.49% (n = 46) of participants experienced no change, while both positive and negative changes were equally reported by 23.26% of (n = 20) participants.

4.2 RQ2: Opportunities for Generative AI

Our results regarding opportunities for GenAI and CoI in online computing courses are presented in Figure 2. When asked specifically about cognitive, social, and teaching presence, we observed average ratings of 3.64, 3.19 and 3.6. This indicates general interest in leveraging GenAI for these elements to foster a community of inquiry in online computing education. However, we found social presence received a lower score compared to other CoI elements, suggesting students believe social presence will be less supported by GenAI. To compare synchronous and asynchronous course participation formats, we found no significant differences in students' perceptions of improving cognitive presence (U = 796.5, p = 0.2968), social presence (U = 861, p = 0.6303), or teaching presence (U = 883.5, p = 0.7744) with the support of GenAI. Students expressed interest in working with AI-generated material, AI co-learners, and AI instructors/TAs, receiving average scores of 3.62, 3.52, and 3.52. When considering having AI-generated course material, participants believe the accuracy of the content (n = 65), clarity of the explanations (n = 64), and inclusion of practical examples (n = 46) are the most important aspects. When considering working with AI co-learner, participants think the most important aspects are clarity and relevance of conversation content (n = 63), naturalness and real-time responsiveness in interactions (n = 57), and ability to assess student's current knowledge level and provide personalized feedback (n = 51). When considering working with AI instructors/TAs, participants think the most important aspects are clarity and relevance of conversation content (n = 65), the ability to assess student current knowledge level and provide personalized feedback (n = 57), and naturalness and real-time responsiveness in interactions (n = 51). We expand on these findings for each CoI element in the sections below.

4.2.1 *Cognitive Presence.*

For cognitive presence, the average score rated by students is 3.64—with most students agreeing GenAI can support cognitive presence. The triggering event, exploration, integration, and resolution factors received 3.53, 3.63, 3.67, and 3.72 average scores. This shows students perceive progressively stronger support from GenAI for cognitive presence as they move from initial engagement (triggering event) through deeper levels of cognitive processing (exploration and integration) to the final phase of problem-solving (resolution). In open-ended responses, participants appreciated the potential of using GenAI for providing **realtime feedback** (P3, P6, P15, P32, P79, P80, P82, P83), **clear explanation and examples** (P2, P12, P45, P50, P55, P60, P61, P65, P71) and **inspiration in a new topic** (P60, P86). P6 appreciated the immediate feedback and examples, stating that "*If TA office hours are not available, it would be great to ask [GenAI] questions and get explanations as often as needed. Having examples of my ideas and AI-generated examples that start from the basics would help improve my understanding of the concepts. (P6)*" P2 found AI is helpful in the decomposition of complex materials, saying:

> *I think incorporating AI course materials can help with learning the material. Sometimes, materials given in class are hard to understand, but with AI it is possible that it can help break down the difficult material and feed it to the students in smaller pieces to help understand the bigger picture. (P2)*

However, participants have major concerns about **accuracy from the generated responses** (P6, P21, P42, P44, P46, P51, P54, P56, P58, P59, P62, P82). For example, P63 mentioned "*There is a big stigma and rational fear when it comes to AI. It's just a risk of misinformation and high chance of hallucination regarding the formation these AI models would bring.*" Also, P54 states:

> *Generative AI is not at a level where I can trust course materials which are generated by it. Most gen AI models have the hallucination problem and it would require human feedback to help correct inaccuracies which is a waste of time. (P54)*

4.2.2 *Social Presence.*

Participants also perceived GenAI could support social presence. Affective Expression, Open Communication, and Group Cohesion received average scores of 3.14, 3.35, and 3.09 respectively. Open Communication scored the highest with an average of 3.35, indicating a relatively stronger perception of the GenAI could promote open communication, with factors like mutual awareness and recognition, contributing to a more engaging and collaborative learning environment. Participants noted that GenAI could be helpful for **reducing pressure for asking questions** (P29, P33, P52, P80) and **improving communication, social interaction and collaborative learning experiences** (P51, P60, P61). As P33 mentioned,

> *I have tried to use AI to help me understand the concept and programming, I think it was great. Because AI is everywhere and every time I could communicate with, and I didn't need to feel shameful about the question I asked. (P33).*

However, many participants indicated a preference for **communicating and learning with real persons** (P12, P25, P29, P67 P77, P78), such as P29 stating "*I find it challenging to get excited about studying with AI classmates. I prefer real interaction with humans - chatting, joking around, and enjoying the learning process. AI seems more like a tool for providing answers, while I crave the studying atmosphere and the companionship of fellow students, rather than having a 24-hour teaching assistant*". Participants also noted the **ethical concerns** of having GenAI as co-learners (P15, P67), such as P67 who mentioned "*They are not real and having any sort of emotional connect to them is immoral*".

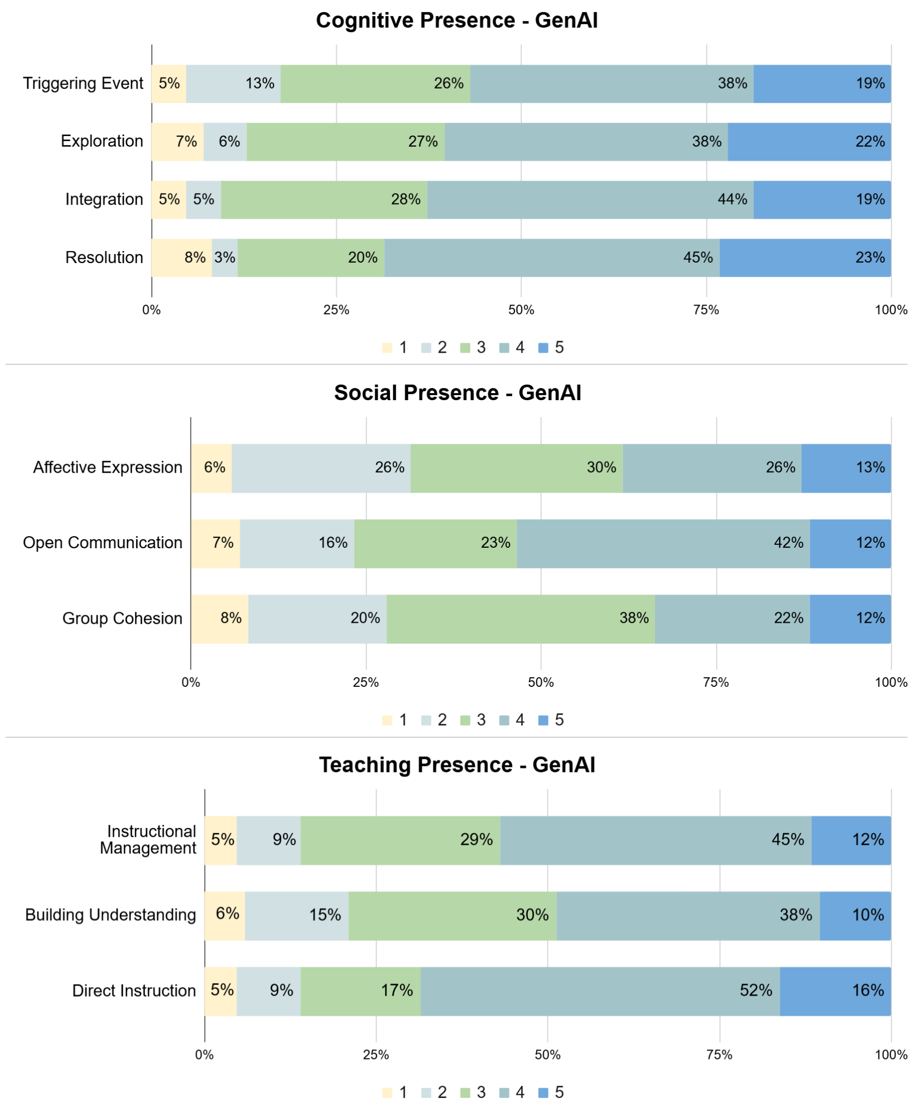

Figure 2: Distribution of participants' perceived Cognitive presence, Social Presence and Teaching Presence with related factors of Opportunities for Generative AI based on a 5-Point Likert Scale (1 indicates Strongly Disagree and 5 indicates Strongly Agree)

4.2.3 Teaching Presence. For the teaching presence, the overall average score was 3.6. This suggests participants believe GenAI can support instructional efforts in online computing courses. The factors of Instructional Management, Building Understanding, and Direct Instruction received 3.5, 3.33, and 3.66 average scores. The higher scores in instructional management (3.5) and direct instruction (3.66) demonstrate that GenAI could effectively support the clear definition and initiation of course topics and concepts, as well as actively provide direct instruction and facilitate course discussions. Participants believed having a GenAI instructor could be helpful for **real-time guidance and feedback** (P7, P15, P29, P51, P52) to support direct instruction. Many participants noted the benefits of AI could help instructional management in providing different method for course content delivery, such as one participant who noted "*I think AI-generated course material can effectively help me understand the class concepts, especially use the customized example I familiar with or explain to the specific point I confused*" (P17).

Some participants believe that AI instructors and TAs have the potential to enhance teaching presence by providing continuous, judgment-free support for students, such as P25 who mentioned, "*I do think having AI instructors is a good idea. Sometimes, I struggle to ask questions in class and fear sounding silly. But if I know I'm asking an AI, I won't have that worry anymore*". Also, P79 mentioned "*I think the idea of having an AI TA is appealing to me because it allows for me and other students to ask questions without judgment of those questions coming off as 'stupid'*". Moreover, P52 highlights how AI instructors and TAs can provide valuable support for students with mental health challenges, sharing "*I'm particularly interested in AI instructors/TA's as someone who suffers from mental illnesses that affect my ability to retain information while also getting uncontrollable anxiety around failing/appearing authority figures like professors*". However, participants also believe the importance of "having a human authority to reduce the risk of misinformation" (P12, P15, P86). For example, P15 mentioned "*Balancing AI integration with human interaction and ensuring the quality, accuracy, and ethical use of AI tools is crucial to maximizing their (GenAI) benefits*". P12 mentioned "*I believe in usage of AI as much as we can for learning new materials and for our studies. But there should be real person that we can connect to whenever we seek for additional help and support*".

Also, P21 shares negative experiences about learning with a GenAI teaching assistant in a computing course, stating:

> *I truly believe that implementing AI co-learners and AI instructors/TAs would destroy the learning experience of computer science topics and tarnish the reputation of any institution that implements a widespread version of it. AI, specifically LLMs like GPT, are not advanced enough to be answering the often nuanced questions that a student will ask. I recall there being an LLM bot within the Computer Systems discord that was supposed to answer questions related to the course and its contents. When using that bot, it answered every question very poorly and was a negative experience for me. (P21)*

5 Discussion and Future Work

Based on our results, we provide implications for enhancing existing online courses and discuss opportunities for GenAI to support a community of inquiry in online computing education.

5.1 CoI in Online Computing Courses

Benefits: Participants reported existing technologies and teaching methodologies in online computing courses have relatively sufficient support for cognitive presence and teaching presence—generally finding online computing courses comparable to in-person learning for various factors. Students appreciate the flexibility in the learning environment, the availability of diverse learning materials, and well-structured course materials. Learners could benefit from these features, as Broadbent discovered in the article, students who exhibit strong self-regulated learning strategies such as time management, metacognition, effort regulation, and critical thinking, have a positive correlation with academic outcomes in online learning environments [10].

Limitations: However, students indicated that social presence in online computing courses is inadequately supported. Our results suggest online environments do not facilitate emotional connection and group cohesion as in-person settings. Students found it difficult to engage in discussion, establish social connection, and develop a sense of belonging within the learning community. The lack of social presence also makes it challenging to effectively implement active learning strategies such as think-pair-share, peer instruction, and group activities [34, 52, 53]. Addressing these is crucial for enhancing stduents' online learning experiences, as fostering a stronger social presence could lead to more cohesive and interactive virtual classrooms and promote learning gains [61, 72]. The challenge is also critical in software engineering education, where collaboration, communication, and teamwork are essential professional skills, and limited social interaction online may hinder students' preparation for real-world development environments [29]. For instance, prior work suggests social skills are critical for effective software engineers [43], emphasizing the importance of improving social presence in online SE education.

Future Research Directions: Our findings highlight several opportunities for future research to enhance the online computing learning experience. First, more work is needed to explore instructional strategies and developing tools with features that can better support social presence. Proximity-based video-conferencing platforms such as gather.town[6] combined with gamification could provide a more interactive and immersive experience for students, allowing them to engage with peers and instructors in real-time, mimicking the dynamics of in-person learning [50, 83]. Additionally, future research should investigate effective strategies for onboarding and training educators to integrate the tools into their teaching practices. For example, Stefanile's work found that, while many tools—i.e., Zoom, Skype, etc.—were adopted in online learning environments, they were underutilized due to educators' limited training and familiarity with online pedagogical strategies [70].

In addition, future research should investigate how enhanced social presence can directly support the development of communication and teamwork skills essential for SE teams. Prior work shows that structured peer review, pair programming, and collaborative learning paradigms improve interaction quality in SE education [29, 33, 55], suggesting that integrating such approaches into online courses could both strengthen social presence and prepare students for the professional practice areas highlighted in SWEBOK 4.0 [75] and other SE curricular guidelines (i.e., [6, 15]).

5.2 GenAI in Online Computing Courses

Perceived Benefits: For cognitive presence, students highlighted that GenAI was especially helpful for breaking down complex tasks into manageable steps, supporting deeper understanding during the exploration and integration phases of cognitive presence. This aligns with prior work in SE literature, as research shows developers believe AI can reduce cognitive load while development tasks [47]. Also, our results show that students noted online courses are often less effective at sparking initial interest and curiosity. GenAI could help address this gap by generating engaging, personalized content and adaptive learning pathways that better initiate triggering events and sustain inquiry [20]. For student perceptions of GenAI for social presence, our results suggest that GenAI can potentially promote open dialogue, enhancing mutual awareness and recognition, thus contributing to a more engaging and collaborative learning environment. For instance, Nakayama et al. found AI co-learners improved performance for crowdsourced workers [54]. Similar approaches can be applied to online computing education. Students believe GenAI can effectively support teaching presence—specifically, the ability to deliver clear, relevant, and responsive instructional interactions. Also, students appreciated GenAI's ability to provide

[6]https://www.gather.town/

timely explanations, nonjudgmental feedback and accessible support, made it easier to seek help without the stress or anxiety often associated with interacting with instructors. In practice, developers report primarily using AI tools for searching for answers to SE-related questions and learning about new concepts and technologies [1]. This highlights GenAI's potential to create a more inclusive and supportive learning environment, particularly for students who may hesitate to ask questions.

Perceived Limitations: We found that students are aware of potential misinformation and hallucinations, raising concerns about the accuracy of AI-generated responses. These concerns highlight the need for improving the performance of the foundation GenAI models [3, 14], integrating mechanisms to verify the reliability of information[32, 58, 68], and training students on critically evaluating AI outputs to ensure effective and trustworthy learning experiences. However, we also found that students were sceptical about the benefits of introducing GenAI to online courses, and some participants are wary of integrating AI in collaborative learning scenarios. Prior work suggests peers can enhance emotional state and academic performance [19], while humans may struggle to communicate and express emotions to large language models (LLM) powered by GenAI in addition to other concerns, such as privacy [35]. Also, our findings suggest that students find it challenging to perceive the same level of social presence for studying with GenAI compared to real human co-learners, and the one-to-one question-answering style makes it difficult to foster group cohesion. Previous work [4] highlights varying levels of trust in GenAI among students, which directly influences their confidence and motivation to use these tools. This trust is crucial for the effective adoption of AI in educational settings. While students noted the potential of AI to enhance teaching presence but were less convinced of its potential to improve social presence, future research is needed to build greater trust and confidence in these technologies.

Research Directions: First, for cognitive presence, future studies could investigate how GenAI-driven scaffolding can be effectively integrated into instructional design. This includes examining how varying levels of scaffolding, from guided questioning to adaptive feedback based on a learner's current level of understanding [40], impact student learning across different skill levels and content complexity. In addition, research should explore how supporting cognitive presence with GenAI may serve as early preparation for AI-integrated software development workflows, where developers increasingly collaborate with AI assistants for tasks such as code generation, debugging, and documentation[1]. As social presence remains the most difficult CoI element to support with GenAI, research is needed to explore how GenAI might simulate more human-like interaction, and explore how GenAI can facilitate not only individual conversations but group social dynamics. For instance, multimodal models could incorporate non-verbal cues to make interactions feel more real, while GenAI powered agents could simulate team dynamics, enabling AI to function as collaborative team members and enhance group cohesion [74]. Beyond simulating interaction styles, GenAI could also act as a facilitator of collaborative practices in SE education. For example, GenAI agents could moderate online discussions by prompting clarification questions, highlighting unresolved design trade-offs, or summarizing existing software development activities that mirror roles in professional SE teams[41, 73]. For teaching presence, future research could investigate models of hybrid instruction, where GenAI handles procedural and low-stakes instructional tasks, while human instructors focus on motivation, engagement, and mentoring.

In parallel with GenAI's potential, the use of GenAI in online education also presents ethical challenges. Besides the misinformation and hallucinations concerns in our findings, students and educators also raise concerns in overreliance on AI tools[79, 82], potential academic dishonesty[56, 63, 81], and privacy [31]. These challenges indicate the need of future research on developing clear GenAI usage guidelines and helping students critically assess and validate AI outputs, providing standards that define acceptable use, promoting transparency, and ensuring equitable learning experiences.

6 Threats to Validity

There are several threats to the validity of our findings. Despite our broad recruitment approach, our survey population consisted of mostly males (60.4%) and all undergraduate or graduate students, with 90% of respondents between the ages of 18 and 25. Our results may not reflect the perceptions of all online learners in computing courses. Future research is necessary to gain insights from a larger and more diverse sample. In addition, we only focus on cognitive, social, and teaching presence in online education based on the CoI framework — yet, other factors can influence engagement in online courses, such as emotional presence [16]. Moreover, although we provided definitions and examples of CoI elements and how GenAI could potentially support them in the survey, students' limited prior knowledge of the framework, together with the absence of examined specific AI tool usage, may have influenced their evaluations. In addition, although we included screening questions requiring prior experience in online computing courses and excluded responses that did not meet criteria, we cannot fully rule out the possibility that some participants misrepresented their background or had limited course experience. Further, we collect limited insights by limiting our survey to only CS and SE students and reflecting on one course. Future work can compare outcomes with other fields and apply additional approaches, such as qualitative interviews and observational methods, to provide a deeper understanding of how CoI are perceived in online computing learning.

7 Conclusion

Enrollment in online computing courses is increasing, offering new opportunities while also raising important challenges for learners. Through an online survey ($n = 86$), this work contributes new insights into how students perceive existing courses supporting CoI elements, and how GenAI can shape their online learning experiences. We find that students view GenAI could enhance CoI elements in online learning, while also raising concerns, and highlight design considerations and research directions for integrating GenAI in learning environments. Our future works aim to leverage the insights to develop AI systems that support the elements of the CoI framework, creating more engaging, interactive, and personalized learning experiences in online computing education.

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