An Exploratory Study of Social Presence in a Collaborative Desktop Virtual Reality (VR) Land Surveying Task

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***Abstract*—This work-in-progress research paper investigates the role of virtual reality (VR) in engineering education lab courses. While there are ongoing debates about the feasibility and practicality of deploying VR on a large scale for engineering instruction, there has been growing evidence in support of the efficacy of VR to promote certain types of engineering instruction[1]. Most importantly, it is essential that we understand students' social interactions in VR-based learning environments. This work-in-progress explores patterns of social presence indicators during a collaborative desktop virtual reality (VR) Land surveying task. Participants were asked to think-aloud and video record their interactions and conversations while completing learning tasks using a desktop VR environment. The desktop program was a computer program that simulates land surveying. The qualitative data analysis was based on the framework of social presence by Rourke et al. [2]. The study reported on indicators, frequencies and patterns or themes of social presence observed during student's interactions with one another in the learning environment. This study also highlighted potential implications of this observation for future research on students' social experiences in VR-based engineering education.**

Keywords—Virtual Reality (VR), Social Presence, Virtual Reality Learning Environment (VRLE), Interaction, Community of Inquiry (CoI).

I. INTRODUCTION

Instructional VR has been implemented as simulation-based VR, avatar image-based VR, projector-based VR, desktop-based VR etc., to facilitate laboratory practices that are similar to those experienced in traditional in-person laboratories [3]. VR uses computer technologies to create 3D graphical representations that simulate the real-world environments in virtual space. VR research has focused on developing human computer interaction using hardware and essential software platforms of computer simulation systems that creates experiences of the virtual world [4]. Learners are partially or fully immersed in the VR environment in a way that increases users' interaction and involvement [5]. Fully immersive virtual reality experience is facilitated by head-mounted displays, tracking systems and high-end computer systems. The system is able to map the learners' movements, thus leading to a feeling of being fully immersed in the learning environment. Non-or partially immersive VR systems may include desktop VR systems [6].

If implemented well, VR has the potential to facilitate positive learning as the learner may be able to visualize abstract concepts, or conceptual and procedural learning experiences that are difficult to support in real-life due to space constraint, high cost or safety concerns associated with doing so. In most instances, learners interact individually with the learning material in the virtual reality environment. However, increasing internetwork connectivity is making it easier to support shared or collaborative VR environments where students can interact collaboratively with other students as they engage with the learning material in a VR environment [7].

As the capabilities of computer connectivity and graphical imaging that VR technology advances, VR is becoming more accessible for entertainment and instructional purposes. Hence, there is no doubt that VR learning environments (VRLEs) will become increasingly important to engineering education. Consequently, there has been a rise in the development of VRLEs of engineering knowledge contents, including in statics, and land surveying, among others. Because VRLEs are emerging technologies, we do not quite know how to support collaborative learning activities in virtual reality. It is unlikely that learners may lack a sense of social presence while interacting with the learning activities in VRLEs. Hence, studies that seek to understand how social interaction enfolds in the VRLEs is important to engineering education research. The community of inquiry (CoI) model proposed by Garrison et al., [8] to explain the types of interactions that occur in computer-mediated or online learning environments can be helpful in studying students' sense of social presence in VRLEs.

Social presence is essential to promoting meaningful interactive engagement in VRLEs [9]. Furthermore, the CoI framework proposes that sustained social presence is necessary for sustaining cognitive and teaching presence in virtual learning environments [10]. Hence, increasing social presence within a virtual learning environment could increase meaningful social and cognitive engagement. However, it is essential for educators to identify indicators of social presence, and how to promote more of such indicators when students interact with themselves and the VRLEs. This work-in-progress study draws on the CoI

model to explore data of student interactive exchanges during a VR land surveying activity. The goal of the study was to examine indicators of social presence and identify patterns that emerged in social presence indicators among participants.

II. THEORETICAL FRAMEWORK

The CoI model (illustrated in Figure 1) developed by Garrison et al., [8] explored the types of interactions that occur in online, virtual, and computer-mediated conferencing. The model proposed that in the community of instructors and learners, deep and meaningful learning occurs through the interaction of cognitive presence, teaching presence and social presence. The intersection of the three presences is necessary for fostering a positive educational experience in online or virtual environments[9]. Social presence deals with the social and emotional aspect of the community of inquiry in which learning occurs. It is the degree of salience of the other person (feeling that the other person is there) in the interaction and interpersonal relationships in a virtual environment. Social presence includes interpersonal emotions of perceiving other people as being perceived real or important i.e., the degree to which a person is perceived to be 'real' in a technology mediated environment [11]. The social presence domain of the CoI aids the community in achieving her cognitive and teaching objectives through social engagements and appeasements in the community. Cognitive presence describes the quality of cognitive engagement in the construction of meaning through sustained reflection and discourse within a community of inquiry. Teaching presence describes the agency of the instructor in achieving an active learning process by designing, managing, and facilitating learning sequences in virtual environments [8].

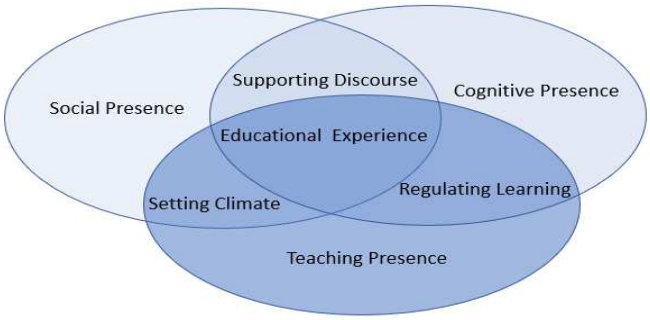

Fig. 1. Elements of an Educational Experience in Community of Inquiry [6].

Some earlier studies proposed frameworks and methodologies for exploring indicators of social presence. Rourke et al., [2] described a template for exploring social presence that they developed to facilitate their analysis of a social presence data in an asynchronous text-based computer conferencing. The authors calculated social density scores by dividing the instances of social presence indicators by the total number of words of the transcript. Using the social density score, the authors compared two transcripts and provided a description of social presence observed among participants during the computer conferencing sessions. Thayalan and Shanthi [12], also reported a study where they qualitatively assessed social presence within a virtual forum. Qualitative data was collected from students who were required to take part in a portal as a requirement for the course. The study found interactive responses (indicative of social presence) were the most fundamental aspects of online interactions. Female participants accounted for a greater percentage of interactions than male participants in the distance learning online programs. The methodologies utilized by Rourke et al., [2], and Thayalan and Shanthi [12] in their studies provide comprehensive insight into the interactions that occur in online environments – which can be relatable to the environment of VR land surveying tasks. Huahui et.al., [13] conducted an exploratory study of collaboration in online peer review groups in terms of participation, interaction, and social presence. Microsoft Visio was used to visualize the message actions in interaction maps. They observed that the level of participation of students in the peer review groups differs. The study found participation was required for collaboration and interaction; however, participation does not automatically lead to collaboration and interaction. Interaction was a prerequisite for collaboration but does not always lead to collaboration.

Engineering activities occur in social and collaborative environments, and social interaction is very crucial to learning in engineering. Instructional VRs tools may have the potential to revolutionize student learning. It is challenging to support the same socialness that drives socio-cognitive engagement and learning in traditional instructional settings [14]. This is due to the fact there is a limited knowledge of the kinds of social presence indicators that are generated during social interaction in VR learning environments. Little is known about the nature of the social and interactive patterns in collaborative VR-based engineering learning environments [15], hence the need for identifying the kinds of social presence indicators that emerge in such collaborative VR-based instructional activities for determining which indicators mostly enhance student learning experience, and how to support them. In this study, we seek to address the following research question:

- What are the patterns of social presence and interaction that occurs in collaborative desktop virtual reality land surveying tasks based on Rourke's et al. [2], template?

III. METHODOLOGY

A. Study Participants and Data Collection

Participants in this study were civil engineering students who engaged in a dyad VR-based learning activity in an engineering course. The students were asked to talk aloud and record their conversations as they interact with each other and with the learning platform. The study activities involved students manipulating virtual theodolites to survey a portion of land. Each dyad logged into a room assigned to him or her to access a VR theodolite environment. A screenshot of the VR land surveying environment used in this study is shown in Figure 2. Participants could navigate the theodolite (seen in Figure 2) and position it correctly by using the mouse controls of their computer systems. They then take the readings of their activities.

The students recorded their conversation as they interacted during the task. Nine videos' recordings of participants' collaborative conversations and interactions were obtained and

transcribed for analysis. The transcriptions were analyzed based on the indicators of social presence described by Rourke et al [2]. The videos of the dyads were labelled A to I for easy identification. Groups A and B had a male and a female dyad, while groups C to I were dyads of male students collaborating in the VR environment.

Fig. 2. A screenshot of VR Land Surveying Environment

B. Data Analysis

The transcripts of the collected videos were produced by enabling live transcription of zoom as playback of the VR activity videos. The transcribed data was analyzed based on a thematic approach. Thematic analysis is a qualitative methodology that involves identifying, analyzing, and reporting thematic patterns in a set of data [16]. The thematic approach was chosen because it allows for basic exploration of themes or identified patterns in a data set. The duration of videos and number of words of the transcripts were shown in Table 1 below.

TABLE 1. DURATION AND NUMBERS OF THE TRANSCRIPT ANALYZED

Group	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Duration (min)	35	33	32	27	38	60	40	36	22
Number of words	1493	626	608	787	1601	888	495	551	868

The transcripts were coded deductively by the principal researcher based on the model established by Rourke et al, [2]. The model (see Table 2 below) highlights three categories of social presence indicators to include the affective, interactive, and cohesive. Affective messages are expressed using emotions, humor, and self-disclosure. Interactive messages are reflected in asking questions, replying to other messages, quoting others, complimenting, and expressing appreciation, and expressing agreement. Cohesive messages are indicated using vocatives like referring to participants by name, addressing or referring to the participants using inclusive pronouns, use of phatic or salutations such as greetings.

TABLE 2. MODEL AND TEMPLATE FOR ASSESSMENT OF SOCIAL PRESENCE, ADAPTED FROM ROURKE ET AL., [2].

Theme: affective	
Indicators	***Definition of the indicators***
Use of emotions	Conventional or unconventional expressions of emotions including repetitious punctuation, conspicuous capitalization
Use of humor	Teasing, cajoling, irony, understatements, sarcasm
Self-disclosure	Details of life outside of class or expression of vulnerability
Theme: interactive	
Asking questions	Asking questions from other students or the moderator
Referring to other messages	Direct references to contents or questions of other participants
Replying others	Replying to what other participants said
Compliment	Expressing compliments and appreciation
Agreement	Expressing agreement with others
Theme: cohesive	
Vocatives	Addressing or referring to participants by name
Group	Addressing or referring to the participants using inclusive pronouns and as a group
Phatic	Use of salutations, greetings, and closures

IV. RESULTS AND DISCUSSION

The transcripts of the videos were coded by identifying the themes and indicators of social presence in each dyad's interactions. Emerging themes are discussed here from the most prominent (the highest number of instances) themes to the least prominent.

A. Interactive

Interactive messages were the most observed social presence indicators observed from the transcripts of the videoed interactions. Figure 3 (below shows that many of the interactive messages were questions (35), agreed interaction which had 31 messages, 17 messages referring to other messages in the form of questions, 14 messages of replies and 10 compliments.

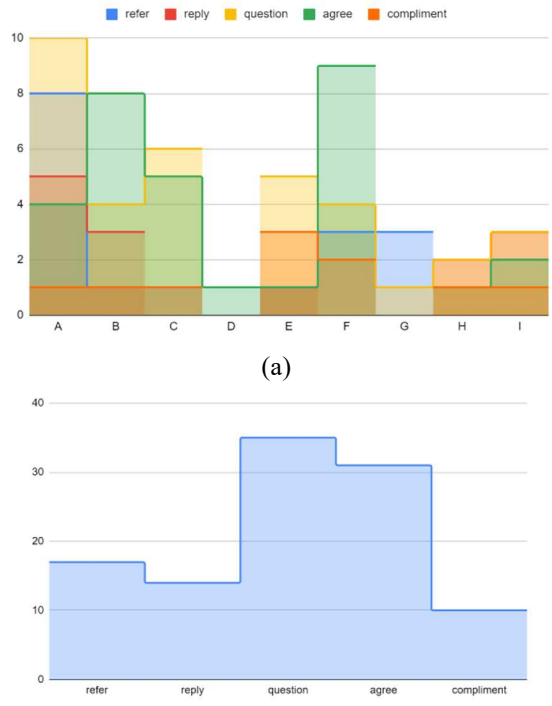

Fig. 3. (a) Number of identified indicators of interactive messages in the VR videos transcripts groups (b) The total number of interactive messages in the task.

Excerpt from the transcript that shows interactive messages is given below:

*22:03:55 and I can share. Do you want me to share my screen with you? **(question)***
*that's going to make a big difference **(agree)***

When compared to the number of cohesive and affective messages, interactive messages were the highest kinds of social presence themes observed. This result supports the findings of Thayalan and Shanthi [12] that interactive messages are the most prominent aspects of online interactions. Eggins and Slade, [17] explained that people who share strong interpersonal bonds (just like old married couples do) tend to express less salutations and compliments than those who share transient or weak interpersonal bonds. This may explain why there are a lot of interactions in the form of questions and agree messages but little compliments for each other's efforts. It may be helpful that the instructor and team leader make conscious efforts to compliment team members and advise the students to appreciate each other's efforts during the VR experiment.

B. Cohesive

As shown in Figure 4 below, most of the cohesive messages are group discussion with 31 messages, 7 messages show phatic and greeting while just 2 messages show vocatives or calling team members by their names.

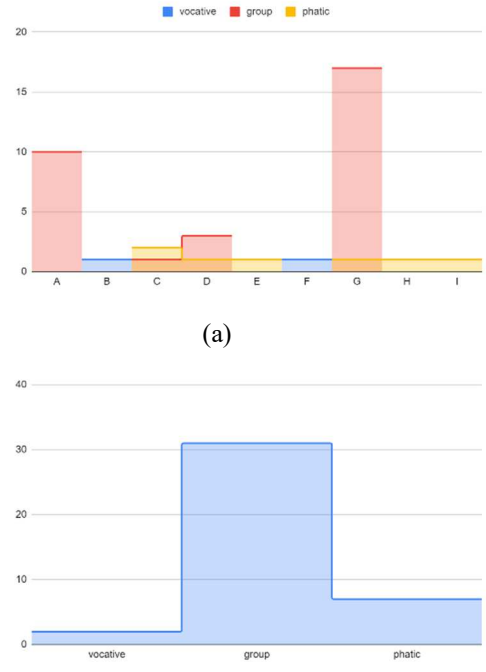

Fig. 4. (a) Number of identified indicators of cohesive messages in the VR videos transcripts group. (b) The total number of cohesive messages in the task.

Excerpt from the transcript that shows cohesive responses is given below:

*17:16:04 So we get our measurements from there. **(group)***

*17:50:40 We're at the station for now we did station 3 great using the data. **(group)***

Group messages accounted for the highest indicators of social presence cohesive responses during the VR land surveying task. A study by Darabi et al., [18] suggests that group discussion strategies that engage learners in meaningful interaction promote higher-level learning engagement and achievement. The phatic or salutations of the virtual environment may be improved if the students greet each other at the start and end of the session and it will be good for students to introduce themselves by names before the VR laboratory session.

C. Affective

The affective indicators of social presence coded included emotional expressions (emotion), the use of humor, (humor) and self-disclosure (self-dis). The result for the affective messages is shown in Figure 5 below. Emotional expressions were the most observed affective indicators of social presence (21 messages), followed by self-disclosure (14 messages) and use of humor (9 messages).

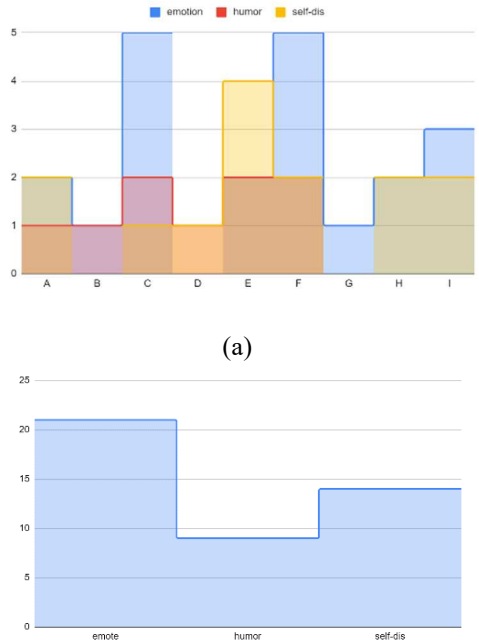

Fig. 5. (a) Number of identified indicators of affective messages in the VR videos transcripts group. (b) The total number of affective messages in the task

Excerpt from the transcript that shows affective responses is given below:

*12:19:41 Wow! Wow! **(emote)** measure*
*13:13:41, come on! **(emote)***
*13:45:18 please tell the truth, which is the yes. I like it. **(humor)***

The affective messages observed were relatively small when compared to interactive and cohesive messages. Limit expression of affective indicators of social presence may have implications for sustaining collaborative team engagement in VR, especially over an extended period of interaction. The results show interactive messages to be dominant in the environment while cohesive and affective messages are lacking

probably due to the social nature of the virtual setting which is different from face-to-face laboratory task. Future research could explore the findings of this work-in-progress research in providing guidance for educators for the optimal use of the virtual learning environment for educational purposes.

V. CONCLUSION

This exploratory study examined patterns of social presence and interaction in a collaborative desktop VR land surveying based on the social presence model proposed in the CoI framework literature. The data examined in this study are video recordings of interaction between students who were colleagues. We found that the pattern of social presence indicators that were observed in the social interactions were similar in proportion to those reported in earlier study – interactive messages were the most expressed, and affective messages were the least expressed indicators of social presence. Therefore, our observations provide some validity for Rourke et. al. social presence model. Drawing on this model, we aim to further explore the implication of the different social presence indicators for social interaction and engagement in collaborative VR-based learning environments. We envisage this effort could provide useful curriculum design tips or prompts to support meaningful engagement for VRLEs in engineering education.

This study lays the foundation for future social presence research on social engagement in VRLEs. In the future, we intend to explore the ramifications of different social presence indications for collaborative learning processes and students' experiences in VRLEs for engineering education. We will further explore whether demographic differences in social presence patterns affect students' interaction in VR activities. We will further explore how the interaction between social presence, cognitive presence, and teaching domain affect students' educational experience in the VR environment.

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