Virtual Reality for Software Engineering Presentations

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***Abstract*—Due to the impact of the pandemic situation, applying online learning methods become an immediate response to tackle the difficulties in teaching and learning, including software engineering courses. Online video meeting platforms (e.g., MS Teams, Webex) are popularly adopted as a medium between instructors and students to conduct online learning classes and they have been modified to provide functions supporting remote teaching and learning activities such as the breakout rooms for conducting group activities. However, maintaining student engagement is still a challenging problem in online learning. Especially, drawing students' attention and enhancing their experience during in-class activities (e.g., project presentations, group discussions) is critical to achieving of activities' objective. Virtual Reality (VR) has been considered to be a potential answer to this online teaching and learning enhancement. This study evaluates the benefit of adopting VR in software engineering class presentation activities. The evaluation result from 3 courses shows that VR improves the online learning and presentation experience by offering visual attractions and presence to students.**

***Index Terms*—software engineering education, Covid-19, virtual reality**

I. Introduction

The Covid-19 pandemic has affected educational systems around the world. At the beginning of 2020, our institution, Mahidol University, and many other higher education institutes [1], rushed to set up remote teaching to continue the student's education. Online collaboration tools such as Microsoft Teams (MS Teams), Webex, Zoom, Google Classroom, and TeamViewer have been utilized depending on the readiness of each institution. While such online tools have improved since the beginning of the pandemic, they cannot assist in all aspects of onsite education. One challenge observed from this distance education is the reduced interaction between the student-student from in-class support [2]. Based on our experience and from our studies in software engineering education, these interactions also play a key role in online learning success [3], [4].

Communication among team members is one of the key success factors in software development projects such as conveying customer requirements to team members. Effective communications and interactions are also required in modern software development (e.g., Scrum meetings, sprint reviews, and sprint retrospectives). Thus, software engineering (SE) education aims to mimic those activities into in-class activities to enable the student's working capabilities. However, the training of those skills in team cooperation can not be fully expressed and reflected through the use of traditional video meeting platforms since they lack presence and limit student interactions. The presentation and discussion that highlight the alignment between software design and its working software require a flexible and seamless continuous presentation space that prevents participants from context-switching.

One possible solution to this problem is virtual reality (VR) technology. In [5], the authors reported that VR could increase motivation and engagement. In addition, social VR platforms can provide the feeling of other students' presence in class than online tools such as Webex and MS Teams [6], [7]. Not only conducting a class but social VR has also been employed for academic presentation in remote conferences [8]. We believe that our SE students can benefit from conducting class activities on social VR platforms. Since, a user can access these VR platforms via browser and headset, all students can participate in the online class activities. Thus, we have conducted a preliminary study for applying a social VR platform for SE class activities in 2020 (see III). From the preliminary study, we have found that the social VR platform improves the students' collaboration resulting in a better presentation. To confirm our finding, in this study we investigated the solution to the drop in student engagement in software design presentations using VR technology in other SE classes.

In this study, we aim to answer the following research questions.

- RQ1: *Can VR give a positive experience in software engineering presentations?* We seek insight into the suitability of VR for software engineering presentations especially in terms of promoting engagement.
- RQ2: *How does VR improve online software engineering presentations?* We want to understand if VR is a better approach than traditional video meeting platforms such as MS Teams or WebEx.
- RQ3: *Does the prior VR experience affect the students' in-class VR presentations?* We want to understand the generality of the potential benefits of VR across the experience range.

To answer these research questions, we learned from the preliminary study and laid out the methodology for this study. After analyzing the results, we found that using VR for software engineering presentations promotes the students' experience, presence, and interactions.

The remainder of this paper is structured as follows: Section II explains the background and related work. We elaborate on our preliminary study in Section III. We then present the

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details of our research methodology in Section IV. In Section V, we present the results from our experiments and discuss the finding and implications of our work. We then conclude our work in Section VIII.

II. Related Work

A. Effects of Covid-19 on Education

As stated in the introduction section, the effects of Covid-19 on the educational systems are reported in all levels, from preschool to higher education [1], [9], [10]. In our institute, many of our students and instructors alike had to rely on 4G, with poor connections, while conducting online activities via Webex and MS Teams. In [11], over 80% of the surveyed instructors in the UK reported that they had access to the tools for online teaching, while only 32.5% of non-computer science programs and 48.8% of the computer science program were confident that their students can access the online contents. The report from [1], however, indicated that class content sharing, online education platforms, and technological adoption were met with a positive experience from teachers and students alike. The highlighted educational process problems in the same report are the teacher-student interaction, training, evaluation, educational outcomes, and personal adaptation to the Covid-19 situation.

As the pandemic is still ongoing in 2022, where on-site and online classes are offered depending on the local Covid-19 situation, we have settled for a long-term change in society. The reports on the impacts, challenges, and proposed solutions to this disruption are still coming in on how the institution is managed, and how the classes are conducted. For this study, we will focus on how the class is conducted. In [12] reports, the students could not cope well with the situation and felt stressed. In [2], the survey on students in a different country from the previous study also indicated that distance education and social distancing reduced the interaction between the student-student from in-class support and from social support.

B. Online Software Engineering Education

Similar to other subjects, emergency remote education forced software engineering education online [13]. In [14], the survey indicated that online learning in Computer and Software Engineering degrees had negative aspects on both teacher-student and student-student interaction. It is shown in [3] that if the channels for communication between teacher-student and student-student are maintained, and the issues in learning are addressed in a timely manner, the software engineering class can be successful. However, the course should be arranged such that the video call meeting and the online session distractions are minimized [4]. In addition, team-building exercises to initiate student-student interactions are also recommended for online classes [4].

In particular, in-class software engineering education activities can be greatly varied based on the objective of teaching and learning and reflect a wide software engineering disciplines. It can also correspond to common software development activities and aims to mimic real practices regarding analysis, design, coding, testing, maintenance, and project management methods [15]. Thus, active-based, project-based, and problem-based learning techniques have been adopted to conduct those activities [16]. It becomes a challenging problem in an online teaching and learning environment. To solve the student-student interaction and the teacher-student issues, our work investigates the use of VR technology for class activities.

C. Virtual Reality (VR) for Remote Classes

Remote classes are commonly conducted via video conferences which may not be adequate when considering the following problems. They support limited interaction [7] by relying mainly on video communication, text messaging, and annotations over shared content. This is usually not sufficient to accommodate the range of activities typically conducted in classes such as those in software engineering. Sense of presence (in this paper, referring to the overall sense of belonging to the classroom including both general and social presence) was found to be limited in video conference sessions [6], [7]. Better presence could play a crucial role in more effective online learning because it correlates with task performance [6] and could promote engagement with class participants [17]. Reduced student engagement during video conference sessions was stated in [6] which could be detrimental to effective education.

Many have considered VR as a method to enhance education because good VR experiences could be clearly recalled and could increase motivation and engagement [5]. Social VR provides an immersive virtual environment that creates a common spatial and social context for multiple users [18]. Studies of remote classes using the "Mozilla Hubs" social VR platform showed increased presence in students relative to when using Zoom-based [7] and MS Teams-based [6] platforms. Social VR also provides richer interaction that could be useful for supporting a wide range of activities in typical software engineering classes or other subjects. In addition to its increasing use in education, social VR has been employed in a remote conference [8], science fair [19] and gallery [20] to seek similar benefits.

There has been a minimal effort in the study of social VR for remote software engineering classes. Our work reports on student experiences of using social VR platforms including Mozilla Hubs, FrameVR, and Spatial.io in three software engineering subjects, compared with experiences when using traditional video meeting platforms.

III. Preliminary Study

In order to deliver class activities on VR platforms and design our studying approach, we conducted a preliminary study to assess the study's feasibility and mitigate any impacts that could affect teaching and learning efficiency in the design of the study. The preliminary study was conducted on a software engineering-related subject, namely ITCS431 Software Design and Development. The objectives of this course are to teach students the theories and concepts of software design based on Unified Modeling Language (UML). Students must be able to apply software design knowledge to develop software models that comply with a set of requirements. The course learning outcomes (CLOs) of this course have been designed to align with the program learning outcomes where the VR project presentation contributes to two CLOs: 1) Students develop software models based on given problems and case studies, and 2) Students can integrate the learned concepts, methodologies, and techniques to design a working software prototype. These two CLOs reinforce the program learning outcomes that focus on the use of systematic approaches and solving problems under the context in which a computer system (will) operates.

VR platforms were used in the term project's activities. The term project was a group assignment that has been designed to mimic the real software and system requirements of the Gemini Observatory.[1] Students needed to design software to control the operations of this big extremely large telescope. There were four main actors (Astronomer, Science observer, Telescope operator, and Supporter) involved in the operations such as science plan submission and validation, command-line mode, and telescope maintenance schedule. The project scope had been adjusted to fit students' workloads and class schedules. The project consisted of two phases. The first phase involved requirement management activities including requirement elicitation, analysis, and modeling. The original Gemini software requirement specification was provided to students for their preliminary study. The second phase focused on software design, implementation, and testing. The students needed to deliver software models using UML diagrams and a prototype. In addition, the project had a constraint that the new software must operate with the legacy software to control the telescope. Thus, the legacy software module had been developed and distributed to students to mimic a project constraint. The delivered software prototype must be compatible with the simulated legacy software.

The students delivered a presentation of their work at the end of each phase. The presentation in the first phase focused on the software design where UML diagrams were mostly delivered in the presentation. The second phase focused on the demonstration of the working prototype. Figure 1 shows examples from the presentation in ITCS431. The students had to prepare an exhibition in the VR space to present software models using UML diagrams and the working prototype corresponding to their design. We also used the annotation feature in the discussion. We used Mozilla Hubs (Section V.B) in the first presentation and FrameVR (Section V.B) in the second presentation.

In this preliminary study, we observed student engagement, student outcome, and student satisfaction from the course evaluation. We collected feedback from 32 students. From the project evaluation, the students were also satisfied with the course learning outcomes. The students mentioned in the course evaluation that the use of VR platforms improves their experience in the presentation activities. Specifically, 80% of the students had never experienced the use of VR in-class activity and 50% realized the benefits of applying VR. In particular, 90% of the students mentioned that using VR allows them to improve their presentation not only through the collaboration between team members but also through the content delivery method. For example, a student said, *"I feel the sense of being inside the virtual spaces and the sense of sharing the spaces with your instructor and friends because I felt that I'm walking with my friend and sharing some experience with them"*. We have noted that to ensure the effectiveness of applying VR platforms in the classes, this teaching approach has been awarded the "Online Engagement and Motivation Techniques, Innovations and Learning Models, Honorable Level" from the Division of Academic Affairs from Mahidol university in 2020.[2] Our study was thus shaped based on the results derived from this preliminary study.

IV. Methodology

To answer the research questions, we performed a within-subjects study that the participants in each course experience two different environments (i.e., conditions). We then compare their experiences from the two conditions. The participants first performed a project presentation and a sprint retrospective activity via traditional video meeting platforms (i.e., condition 1) and later were exposed to a virtual reality platform and performed similar activities (i.e., condition 2). The project presentations and the sprint retrospective activities in both cases were performed in a group of 5-7 students and took around 15–20 minutes. The presentations involved showing software design artifacts (such as use case diagrams, data flow diagrams, activity diagrams, and sequence diagrams), and test cases. It also includes the demonstration of working software that was implemented based on those software design artifacts. The retrospective activities include a group discussion to gather the team's past experience during the last sprint, and improve the development process for the incoming sprint.

A. Inclusion Criteria

The participants must satisfy the following inclusion criteria to be included in the study.

1) The participants must have been studying or teaching computer science, information and communication technology, or similar program for at least 1 year.
2) The participants must have experienced both traditional in-class study and online study via traditional video meeting programs.

B. Tools

In this study, we chose three virtual reality tools and adapted them to online teaching and learning: Hubs[3], FrameVR[4], and Spatial.io[5]. The three tools are online and free (or free with

[1] https://www.gemini.edu/

[2] https://bit.ly/mu-teaching-award

[3] https://hubs.mozilla.com

[4] https://framevr.io

[5] https://spatial.io/

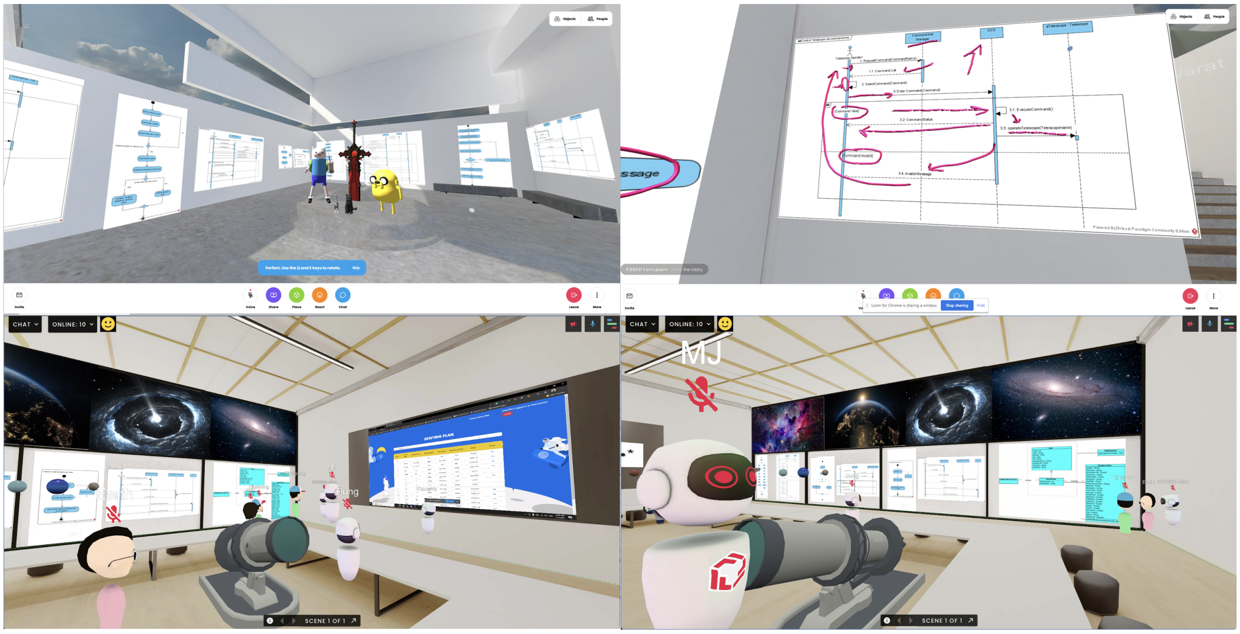


Fig. 1: Screenshots from ITCS431's presentations conducted on Mozilla Hubs (top) and FrameVR (bottom)

some restrictions on the number of users) and can be accessed via a web browser.

Mozilla Hubs is an open-source VR chatroom created by Mozilla. It supports both VR headsets and web browsers. After creating an account, the users can create their own room and share the link to join the room with other users. It has been used in several types of activities, including academic conferences (such as IEEE VR 2020, virtual classrooms, and galleries) but with the recommended limit of around 25 users in a room before performance drops. The created room is permanent and can be re-accessed via the room link.

FrameVR is a closed-source online VR meeting space. It is created by Virbela and similarly allows a user to create a room (called frame) and share a room link with other users to join. The FrameVR version that is used in this study allowed 25 users per room without additional payments (currently, the limit is decreased to 15 users). Similar to Hubs, the created room can be re-accessed anytime using the room link.

Spatial.io is another closed-source online VR meeting space created by Spatial Systems. The maximum limit of users per meeting room is 50 users. Similar to Hubs and FrameVR, the created room can be re-accessed anytime using the room link.

Hubs and FrameVR allow the users to choose their avatar from the predefined catalog or to upload their own avatar, while Spatial.io creates an avatar based on the actual user's appearance. The three systems also allow the users to turn on their video cameras. The users of the three VR platforms can navigate through the virtual space and interact with objects by using control keys on the keyboards (such as W-A-S-D or arrow keys) and mouse clicks. The three platforms can be accessed via a web browser or a VR headset.

C. Course Design and Practice

This study has been conducted on three software engineering-related courses in the Bachelor's degree in information and communication technology program (ICT) and the Master's degree in computer science program (CS) at the Faculty of Information and Communication Technology, Mahidol University. Two of them are taught at Bachelor's degree level and one course is for a Master's degree. The two programs (i.e., ICT and CS) applied the concept of constructivism and essentialism in which learners must be able to construct knowledge rather than just passively take in information. Moreover, the design of teaching and learning methods is based on Outcome-Based Education (OBE). The graduates are expected to achieve the program's expected outcomes by focusing on the capability to use systematic approaches by critically thinking to solve problems in the context of computer systems can operate.

Table I shows the details of the three software engineering courses (2 in ICT and 1 in CS). In this section, we briefly discuss these three courses and the term projects used in the study. Moreover, since all courses had to be conducted online during the pandemic situation, the teaching and learning activities were mixed between synchronous and asynchronous learning. The interaction-based lecture was used to deliver the explanation and discussion of the theories and concepts via MS Teams and Webex. The GitHub issues were also used for discussion outside the class. Specifically, the students could post their questions regarding the content and the term project.

1) ITCS371 Introduction to Software Engineering: This course aims to teach students the fundamentals of software engineering including the concepts, software development process both traditional software development model and modern

TABLE I: Courses participated in this study

Course ID	Course name	Level	Credits	Degree	Meeting Platform	VR Platform
ITCS371	1/2021 Introduction to Software Engineering	3rd-year	3	Bachelor	MS Teams	FrameVR
ITCS473	1/2021 Software Quality Assurance and Testing	4th-year	3	Bachelor	MS Teams	Spatial.io
ITCS521	1/2021 Agile Software Product Management	1st-year	3	Master	Webex	Spatial.io

software development model (e.g., Agile), the basic components of project management, and requirements engineering (including requirements elicitation, gathering, and processing techniques). The students are taught requirement analysis and modeling using use case diagrams, context diagrams, and dataflow diagrams. This course also covers software architecture design, interface design, software implementation process, and software testing. The course learning outcomes (CLOs) involve the student's capability to explain software engineering foundations and concepts and develop software models based on given problems and software requirements. Students must be able to solve software engineering problems, including the specification, design, implementation, and testing of software, and systems that meet specifications, performance, maintenance, and quality requirements.

In ITCS371's term project, students were assigned to design and develop software modeling (i.e., use case diagram, dataflow diagram, and functional decomposition diagram) for a given set of requirements such as an online shopping system, co-working space management system, and fitness and sports club management system. The project consisted of two phases. The first phase of the project involved requirement elicitation activities. In this project, the first set of requirements was delivered to students in the form of an interview video where ITCS371's instructors performed as a customer/client who requires students to develop software (i.e., role-play). The students delivered the analysis of the requirements in terms of the list of functional and non-functional requirements, use case diagrams, and use case narratives. In the second phase, the students had to deliver dataflow diagrams, UI design, test cases, and a prototype. In this phase, the students also presented their projects and we conducted the presentation via a VR platform for this study (see Figure 2).

2) ITCS473 Software Quality Assurance and Testing: The course's main objective is to educate students to understand the relevant topics in fundamental software quality assurance and testing (SQAT). With the knowledge learned from this course, the students can further acquire their new knowledge in SQAT from the ever-growing state-of-the-art tools and techniques in the area. The course aims to enhance the student's abilities to deliver high-quality software. This course covers testing techniques and mechanisms that can be used throughout the software development life cycle to reduce software defects, including identifying root-cause problems in the development process and preventing software defects from occurring.

The term project of this subject consisted of two phases. The first phase required students to select one of the available Java open-source projects from GitHub for example, JFreeChart and Apache Tomcat. The students then needed to study the project's existing automated testing framework and develop additional unit test cases for the project. Then, in the second phase, the students had to develop test cases for their own projects developed in another software engineering subject. The project presentation was conducted on a VR platform. It covered the description of students' design test cases and live demonstration of automated testing executions on their project. This required the students to adapt their presentations using not only static presentation slides but also performing live screen sharing on VR. Figure 3 shows the examples of screenshots from the presentations. The students had prepared the VR room to present their test cases and demonstrated the running of the testing scripts. This involved different types of content that students needed to deliver.

3) ITCS521 Agile Software Product Management: This subject is offered in the first year of the Master's degree in Computer Science. The subject covers agile values, principles, and practices, managing an agile team (roles and responsibilities), product discovery, agile planning for software products, agile development process, testing with agile, and agile metrics. This course aims to use the agile process to practice software product management that involves ideation, requirement management, design, effort estimation, planning, and testing in class and project activities. The course also covers trends in software development including technologies, tools, and related research topics.

Students practiced the techniques to identify business opportunities in a startup context (i.e., ideation activity) to develop a project using agile processes and techniques in the term project. In the ideation process, students had to conduct an interview with customers to extract customers' pain points and develop project ideas to address those pains using the opportunities canvas. The students then used Scrum in the development of their software prototype including backlog grooming, sprint planning, sprint execution, and sprint retrospective. The final presentation and the sprint retrospective activity were conducted using a VR platform. Especially, the sprint retrospective was performed using the simulated Post-it feature to conduct the activity. Figure 4 shows examples from the final presentations and the sprint retrospective conducted on Spatial.io.

4) Procedure: The three courses consist of 15-week lectures and activities. For each of the courses, The students studied the contents in the first half of the course (weeks 1–7) and performed the project presentation or scrum meeting via MS Teams or Webex in week 8. In the second half of the course (weeks 9–14), the students continued their studies and performed another project presentation or scrum meeting in week 15, the last week of the course, using Hubs, FrameVR,

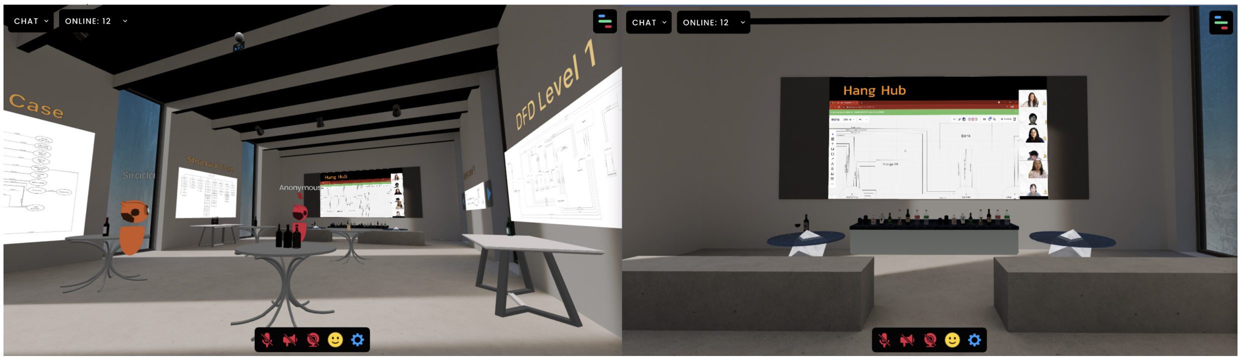


Fig. 2: Screenshots from ITCS371's presentations conducted in FrameVR

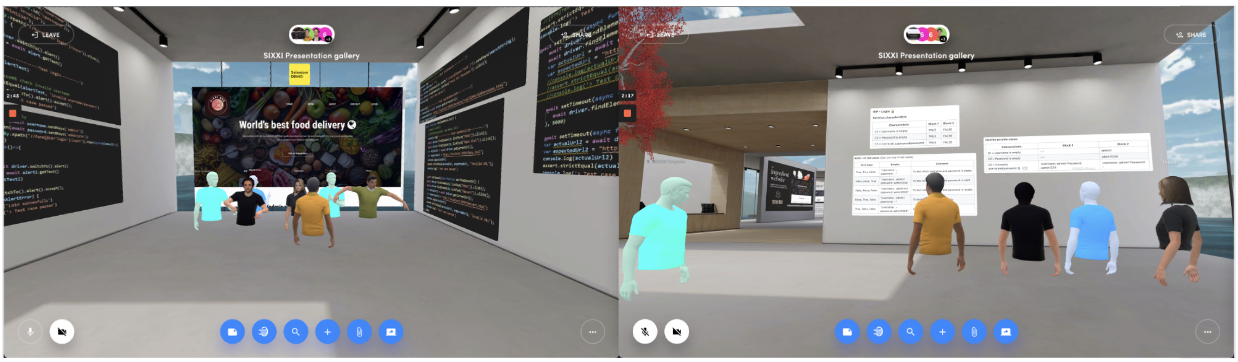


Fig. 3: Screenshots from ITCS473's presentations conducted on Spatial.io

or Spatial.io. The materials presented and discussed during the presentations and the scrum meetings were different according to each course's learning outcomes.

In the VR platforms, the students were allowed to design their own way of presentations or scrum meetings. They could decide to put software design artifacts anywhere in the virtual space and design how the presentation should be delivered, e.g., guiding the instructor through a sequence of rooms covering different types of software design diagrams that they created. The students joined the VR platforms mainly via a web browser but a few had joined using a VR headset.

D. Evaluation: Online Survey

We use an online survey as a tool to evaluate the experience of using VR for software engineering presentations and also to compare it to existing video meeting platforms. We created the online survey by following the guidelines suggested by Kitchenham and Pfleeger [21]. First, we searched the literature for existing work that relates to using VR in education and we have incorporated some of the questions from the study by Cicek et al. [22] with slight modifications to fit within our study's context. Second, we added demographic questions and our own VR-related questions and grouped all the questions into 3 groups: General Experience, Presence, and Interaction. We have a total of 14 VR questions as shown in Table II, rated on a 5-point scale (1 indicates strongly disagree and 5 indicates strongly agree). The questions that are reused from the existing study are marked with $*$. Then, we gave this online survey to the students after they finished their presentations or scrum meetings. Lastly, we collected the online survey results from all the courses, combined them, and performed the analysis.

V. Results

We received a total of 39 responses from the students in the three subjects. There are 9 master's students (first year) and 30 undergraduate students (13 third-year students, 16 fourth-year students, and 1 fifth-year student respectively). Regarding the students' familiarity with VR (Table III), 10 students had already begun using VR, while 24 students were aware or slightly aware of VR. 13 students have tested VR outside of school, which implies that they may have VR equipment at home or used VR platforms before. Regarding the frequency that the students use VR (Table IV), 2 students use VR very frequently (more than or equal to 10 times). 6 and 18 students use VR fewer than 10 times and 5 times respectively. 13 students have never used VR before.

Before we performed any analysis on the survey answers, we measured the internal consistency using Cronbach's alpha. From these 39 responses, the Cronbach's alpha is 0.783, which is an acceptable level of internal consistency. Next, we applied descriptive analysis to the responses. The results are shown in Figure 5, and the results from all the participants are displayed in Figure 5a. Figure 5b, Figure 5c, Figure 5d show the results from ITCS371 Introduction to Software Engineering, ITCS473 Software Quality Assurance and Testing, and ITCS521 Agile Software Product Management respectively.

Fig. 4: Screenshots from ITCS521's activities conducted on Spatial.io

From the results, we have made the following observations.

1) Observation 1: Students find VR visually fascinating, supporting learning experience, and entertaining: The scores of Q1–Q5 are mostly between 4 and 5 both overall and in each course. This shows that the students find VR visually fascinating (Q1), making time passes faster (Q2), turning learning into entertainment (Q3), wanting to explore more about the discussed content (Q4), and developing creativity in their presentations (Q5).

Some students gave us more detailed explanations regarding this point in the free-text answers. One student mentions *"I think it's more attractive and interesting than just sitting still in front of computer and just listening lectures."* Regarding the presentation, three students describe: *"I do feel more fun presenting and answer than normal team session."*, *"If the learning point of view and presentation work is very good for this use. In the event that the work is an activity."*. *"Yes, it's really exciting to see friends in the avatar and it also makes the presentation more interesting."* One student feels that they were entertained and engaged by the presentations on the VR platform: *"Although not very immersed I feel very entertained while using the platform. It really help me stay engaged with the class instead of distracted by something else."*

> **Answer to RQ1:** To answer RQ1, *we found that VR improves the experience in software engineering presentations by giving visual attractions, supporting the learning experiences, and making the presentations entertaining and engaging.*

2) Observation 2: Students agree that VR gives a better feeling of presence than traditional video meeting systems: The overall result and the course-specific results for ITCS371, ITCS473, and ITCS521 are shown in Figures 5a, 5b, 5c, and 5d respectively. Looking at the scores of the answer to Q8 (*Being able to see and experience various locations such as a classroom, presentation hall, and poster conference room, provided by VR, inspires and intrigues you.)*, the students agree that the VR systems allow them to freely explore locations during the presentations. For Q9 (*While I use a VR system, I feel like I am presenting in the real world.*) and Q10 (*While I use a traditional video meeting system like MS Teams or Webex, I feel like I am presenting in the real world*), the average value of the answer to Q9 is higher than Q10. The answers to our free-text questions regarding this point are as follows. One student mentions *"I did feel the sense of being inside the virtual space as well as being feeling closer with my peers due to being able to interact normally. The only downside is that it doesn't feel really much realistic due to the real me still being in front of computer."* Another student says *"Yes i feel the presence of everyone who is here. To see people walking around its make me more fun."* Two students express their impression as *"It really feels that we are actually with the other and sharing a great experience together."* and *"In my opinion, it feel like the same in normal class which many of friends or teacher and can talk to each other when they come nearly. I think it support for learning in online very much."* One student compares VR to video meeting platforms as follows *"Yes, it looks like I can see each other more than learn in msteam or Webex even I didn't see his/her face."*

The higher average score of Q9 than that of Q10 and the free-text answers showed that the students found that the feeling of using a VR system is more like presenting in the real world than using a traditional video meeting system like

TABLE II: Online Survey Questions

ID	Question
General experience	
Q1*	The visual stimuli provided by VR systems are fascinating to you.
Q2*	Time passes faster for you while you consume content via a VR system compared to consuming content via regular 2D displays.
Q3*	Introducing virtual reality into the classrooms turn learning into entertainment.
Q4*	Due to the simulation and experience of VR, you want to explore and learn more about the discussed educational content.
Q5*	Virtual reality develops your creativity in presentation.
Q6	If you have a chance to observe and listen to other people or group presentations with the help of a VR system and a traditional video meeting platform, you feel that they present better in a VR system than traditional video meeting platforms such as MS Teams.
Presence	
Q7*	While I use a VR system, I am always aware that I'm in a virtual world and that none of it is real.
Q8*	Being able to see and experience various locations such as a classroom, presentation hall, and poster conference room, provided by VR, inspires and intrigues you.
Q9*	While I use a VR system, I feel like I am presenting in the real world.
Q10	While I use a traditional video meeting system like MS Teams or Webex, I feel like I am presenting in the real world.
Interaction	
Q11*	Interaction with real people in the real world, whether they are lecturers or students, is necessary for this particular lecture/presentation/discussion.
Q12*	You have a better learning experience through interactions in VR.
Q13*	With VR, I am not limited to passively consuming information and images displayed on the screen.
Q14*	With the help of virtual reality, you can react better in certain situations such as impromptu questions, and unresponsive audiences.

∗Questions from Cicek et al. [22].

TABLE III: Familiarity of VR

How familiar are you with the concept of VR?	Frequency
Aware of VR and beginning to investigate the topic	12
Only slightly aware of virtual reality	12
Already begun using virtual reality	10
Plan to use or make use of VR over the next year or two	5

MS Teams or Webex. However, it is interesting to note that not many students gave a score of 5 to these two questions. This shows that although a VR system can give a better presence while performing a presentation, it is still not the same as in the real world. This is also supported by the scores of Q7 (*While I use a VR system, I am always aware that I'm in a virtual world and that none of it is real*) which is at least 4 in all the groups. Thus, the students agree that the VR systems that they experienced still could not give the feeling of presence in the real world to them. Moreover, from the responses to Q11 (*Interaction with the real people in the real world, whether they are lecturers or students, is necessary for this particular lecture/presentation/ discussion.*), most of the students agree that this kind of activity needs real-world interactions. Some students address this point as follows.

TABLE IV: How Frequent the Participants Use VR

How often do you use VR?	Frequency
Never	13
Fewer than 5 times	18
Fewer than 10 times	6
More than or equal to 10 times	2

One student suggests that using VR on a website does not offer much of a presence: *"Not that much, Despite that VR has different feeling and has more interaction with my classmate, but it can't replace the real presence. (Unless I'm using the VR glasses)"*. Similarly, another students mentions the need of head-mounted display: *"I don't feel much about sense of being. I think i should use some gadget just like HMD or goggle to get more sense."* Another student points out the technical issue that reduces the feeling of presence: *"Yes but some how the lag are making it feels unreal."*.

3) Observation 3: Students find that the presenters present better in VR than in traditional video meeting platforms: From the scores of Q6, most of the students agree (average score of 4 from all participants groups) that if they have a chance to observe and listen to other people or group presentations with the help of a VR system, they feel that the presenters perform better in a VR system than traditional video meeting platforms such as MS Teams. Nonetheless, the survey responses from students in ITCS521 have an average score of 3 (neutral). We believe that since the presentations that the presenters had in this course mainly focused on agile practices, they may not feel the same way.

4) Observation 4: Students enjoy more interactions in VR platforms compared to traditional video meeting platforms: Regarding interactions, we can see from the scores of the answers to Q11–Q14 that the students think the VR systems offer them a new way to interact with their classmates and instructors. The four questions received high scores with mostly an average score of 4 to 4.5.

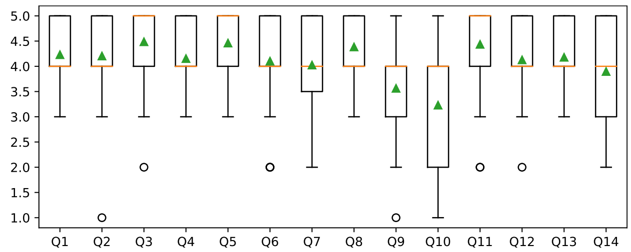
The students explain interactions in VR systems in our free-text question as follows. One student says *"It quite fun that our avatar can interact with others."* Another student describes that *"I feel it's more interactive than the standard meeting software."* One student expresses that *"Yes. I feel think it is an alternative way to interact with friends and instructor better than just normal question-response. I can move an avatar in the provided space which give me a more sense of sharing than typical presentation."*

Answer to RQ2: We found that the students feel more presence and have better interactions during the presentations in VR compared to traditional video meeting platforms.

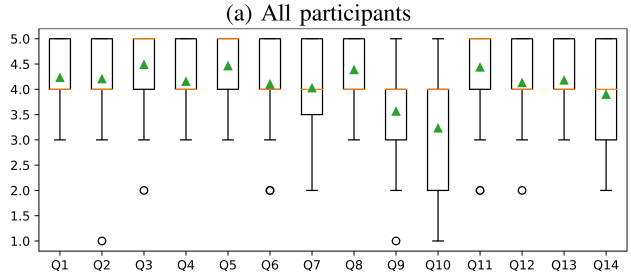
5) Observation 5: Students with prior experience of VR get more good experience from presentations in VR: To answer RQ3, we performed a breakdown analysis according to the group of students who have different frequencies of using VR (Table IV). Note that, Q1–Q5 asked for students' general experience in their role as presenters. However, Q6 asked for students' general experience in their role as listeners. As a presenter (Q1–Q5), we found that the students with the highest experience scores from using VR to perform software engineering presentations are the group that uses VR more than or equal to 10 times, followed by fewer than 10 times, fewer than 5 times, and never respectively. As a listener (Q6), we found the opposite result. For Q1–Q5, the students with higher experience with VR tended to be more simulated in the presentation than the lower experienced ones. This may be affected by the readiness of the students for using VR. The students that frequently use VR may have better equipment and familiarity, thus making them experience the VR presentations better. This matched our observations during class activities, where the students who frequently used VR could use more VR features to help their presentation than the other groups. The same reasons may also explain why the score in Q6 is the reverse. We believe that the students with the highest experience scores from using VR feel that other students' presentations in VR did not differ from video meeting platforms. However, the students with the lowest experience scores from using VR feel that other student presentations in VR were better than video meeting platforms. At the same time, they may perceive the other students' presentations as similar to traditional video meeting platforms because the other students did not have the same readiness and familiarity.

Some of the free-text answers regarding the readiness of using VR platforms include *"Due to some technical issue of the program, I could not see anyone avatar even if there are participants in the room."* and *"yes, I felt the feeling of being in a virtual space but sometimes I'm so confused."*

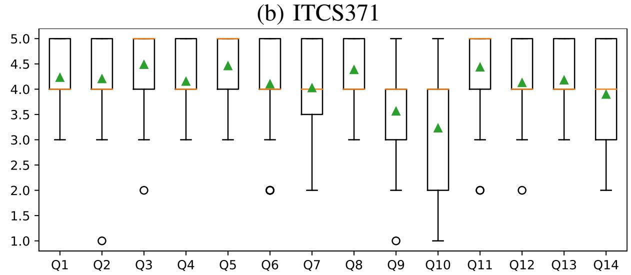
> **<u>Answer to RQ3:</u>** We found that the students with prior VR experience had good experiences when presenting in VR. Nonetheless, they also found other students' presentations were not different than traditional video meeting platforms, possibly due to other students' low familiarity and readiness with VR.



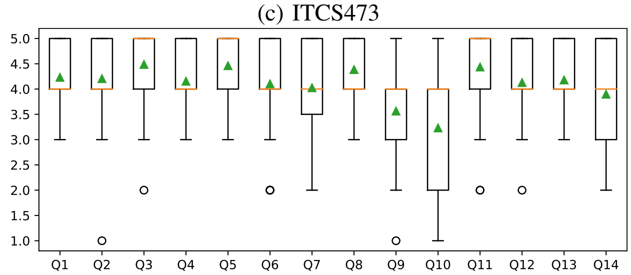
(a) All participants



(b) ITCS371



(c) ITCS473



(d) ITCS521

Fig. 5: The scores of the 14 VR questions separated by course represented by a box-and-whisker plot with circles indicating outliers and triangles indicating means

VI. Discussion and Implication

For SE instructors: This study shows that software engineering instructors can benefit from using VR for their student presentations in online learning. Thus, instructors can consider blending VR into their teaching and interactions with students both during and outside of class time. One suggestion before utilizing VR in your class is to train the instructors, teaching assistants, and students about VR ahead of time. A short ice-breaking activity that showcases VR space was a great introduction to the tool for our classes.

For researchers: Based on our study and our experimentation with VR, we believe that VR could be a great tool for online classes depending on the activity, the number of participants, and computational resources for class participants. One benefit that we observed from VR usage is its space. One can utilize additional space in VR more than that in the real classroom, and other online collaboration tools. Objects can be placed in the VR space such that multiple objects can be viewed at the same time. For example, while one object shows the comparison of two SE frameworks, we can construct two additional objects to showcase the impact of the differences in actual projects. We found this to be an effective way to teach a framework that contains multiple concepts. The research challenge is to find the balance between space utilization and the participant's attention and learning ability. One other limitation was the required VR bandwidth, especially when many objects were placed in VR space. For students with limited bandwidth, they cannot enjoy what VR has to offer. If it is possible to find a solution to this part, students and instructors would be able to utilize this technology for larger classes and activities.

VII. Threats to Validity

Internal validity: In our study, we performed a within-subject study by having the same group of students in each course presented on a traditional video meeting platform, MS Teams or Webex, and later having them presented on a VR platform. This fixed ordering of presentations, i.e., traditional video meetings followed by VR platforms, may lead to bias in the experiment. Moreover, we did not control the experience of the students regarding VR as we believe it would better reflect the real-world situation. However, this may lead to some students' experience in VR being affected by technical issues due to their computers were not suitable for using VR.

External validity: This study focuses only on the presentations. Thus, the findings may not be applicable to other learning activities such as lectures or group discussions. Moreover, we covered 3 software engineering courses in this study (Introduction to Software Engineering, Software Quality Assurance and Testing, and Agile Software Product Management). The findings may not be generalized to all software engineering subjects.

VIII. Conclusion and Future Work

Due to the impacts of the Covid-19 pandemic on educational systems, the use of online collaboration tools become an important component to tackle challenges in conducting remote classrooms. While the teaching and learning activities are mostly one-way communication (i.e., instructor-to-student) but it also incorporates multi-way communications (i.e., student-to-instructor, student-to-student), especially, in a class presentation activity. Our study thus investigates students' experiences and feedback from applying VR to promote students' experiences during online in-class presentations. The experimental results conducted on three software engineering-related courses shows that VR improves student experiences and promotes interactions between participants compared to traditional video meeting platforms. Our future work would involve the expansion of case studies in both a number of courses and different forms of activities. In addition, we will compare the physical onsite SE education with that of online to find key indicators of which type of activity can be conducted online, and which type of activity should be conducted onsite.

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