Evaluating the Effect of 3D World Integration within a Social Software Environment

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***Abstract*—Several virtual communities have spread during the last decade where hundreds of people interact and socialize. Users use these communities in many fields including education, health, business, and entertainment. They use them to communicate, share information, and collaborate to achieve common goals and finish their tasks.**

To our knowledge, no existing literature or research studies shown the benefit of using virtual world in 1) improving software engineering education, 2) enhancing the collaboration in distributed software development environment, and 3) increasing their effectiveness in the distributed developers' progress.

For this purpose we conducted a case study to test effect of integrating a virtual environment called CVE in software development environments. This study presents both qualitative and quantitative analysis of the data collected from the case study surveys and log files. It conducted a survey on the users' preferences a. Also, it collected data about the developer's interactions with the 3D objects, and analyzed the collected results.

Keywords—3D World; CVEs; IDE (Integrated Development Environment); Virtual Environments; Social Interaction; Social Networking.

I. OVERVIEW OF CVE

3D virtual environments (VEs) have been used for a variety of contexts including teaching in classrooms, distance learning, business, and e-commerce. As seen in today's computer games and virtual world simulations, VEs provide the user with the amazing experience of moving around and interacting with a simulated world [1], [2]. As mentioned in [3], virtual environments can be defined as "computer-generated, three-dimensional representation of a setting in which the user of the technology perceives themselves to be and within which interaction takes place." As the technological barriers to creating VEs have decreased, researchers have created many collaborative virtual environments (CVEs) to serve various domains.

A CVE [4] can be defined as an environment that "actively supports human-human communication in addition to human-machine communication and which uses a Virtual Environment (including textually based environments such as MUDs/MOOs) as the user interface." The CVE used for this study is (rather uncreatively) named CVE (http://cve.sourceforge.net/), an educational platform that was built primarily to support two uses: (1) distance learning within by collegiate and computer science students; and (2) software development and group collaboration.

In this article we introduce a virtual environment called CVE, which is a multi-platform collaborative virtual environment where users can interact with each other within a 3 D virtual world. The collaborative virtual environment provides developers with a general view of other users and what they are doing. It allows developers to chat via text or VoIP with other team members and with developers from other teams in real time.

This rest of this article is organized as follows. Section 2 presents research related to this work. The format and setup of the study appear in Section 3. This is followed by a discussion of the results generated from the study in Sections 4 and 5. Finally, Section 6 concludes the article with a short summary.

II. RELATED TOOLS AND RESEARCH WORK

In the area of networked educational virtual environment much research work has been done. This resulted in hundreds of tools and virtual environments that target the educational and training fields. This section shed the light on few research cases and tools.

Arya et. al [5] presented three case studies to validate the effectiveness of using 3D virtual world as a learning environment. They conducted three case studies through Carleton Virtual, a 3D virtual environment for Carleton University. They claim the benefit of using 3D space as a learning environment, and argue that virtual environments introduce a new educational paradigm.

A study had been held by Forterra Systems to explore the promise of using 3D world, and to examine/identify virtual worlds as an alternative to the other teleconferencing and communication tools. Based on the 3D world experience, they believe *"that 3D worlds provide a new and effective learning delivery platform"*[6].

The U.S. Department of Energy uses a web-based 3D virtual environments to change the way online education and training are delivered. They integrate training by providing studies and challenges from inside the 3D world [7].

Researchers at Stanford University's Virtual Human Interaction Lab claim that *"when people entered a virtual world in which their avatar was active (running, playing soccer, etc.), they were much more likely to be physically active in their real lives, that day or the next, than people who found their avatars hanging out and/or lounging around."* [8].

Other researchers studied the effectiveness of 3D worlds for health programs [9], [10], [11]. As an example, researchers from University of Houston found Second Life a valuable environment in the effort to control obesity. They

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TABLE I. SUMMARIZED DATA COLLECTED FROM THE SURVEY DISTRIBUTED DURING THE STUDY.

Participants (Total)	**Participants responded to the survey (Total)**	**Participants suggested/liked tools integration inside the CVE (%)**					
			Chat	**Email**	**Wall**	**Newsfeed**	**SN Features**
7	7	***Like***	***100%***	***100%***	***100%***	***86%***	***100%***
		Used	***86%***	***57%***	***57%***	***N/A***	***N/A***

claim that *"a multicultural obesity prevention project conducted entirely in Second Life,"* was a success for the participants.

III. STUDY

Software Engineering and related subjects aim to teach students how to do collaborative work and enhance their programming expertise. This study was implemented during the *"CS120: Computer Science I"* class at the University of Idaho, in Summer 2011. The study tests the hypothesis that claims that

"integrating a 3D virtual environment within the IDE adds a social environment and provides a "social presence"- the sense in which developers feel that other developers are present in the development environment".

In this study, the population consisted of 7 students, enrolled in the University of Idaho CS120 course, in the Summer of 2011. Every participant that was involved in the task belonged to a group of two members; participants were randomly allocated to these groups. The task was scheduled to take between 45 and 60 minutes. Before the participants started the session, a printed document with instructions about the task was distributed and the instructor made sure that everybody was aware of their part of the task; a short training session (30 minutes) was held to make the participants familiar with the features available inside SCI and the objective of the study in order to make their job easier. Table I introduces a brief statistics to the participants' nature, tools they used, and tools they would like to see integrated in the system.

A. *Questionnaire Design and Measures*

After completing the task, students were asked to fill out a survey to answer questions about their experience while using the SCI system, the difficulties they faced, and things they liked and things they didn't like about the system. The questionnaire is designed to obtain preliminary feedback on the SCI system and its implementation. It contains both open and closed questions and is designed to measure the effect of the SCI system in the classroom. The question on this questionnaire were based on the ISONORM 9241/110, Subjective Impression Questionnaire [12]. The questionnaire was given to participants at the end of the study.

Participants were required to respond to closed statements on a Likert scale where they needed to specify their level of agreement ranging from the response "Strongly Agree" = 5 to the response "Strongly Disagree" = 1. Other questions are also asked so participants can suggest features they would prefer/like to integrate within the collaboration space.

B. *Goal*

There is one main observation goal of the case study; the goal is to evaluate the usefulness of integrating virtual environment in distributed development environment, and to investigate the benefits of the SCI system features and their role in increasing awareness among distributed developers.

This research obtains data from this case study and uses this data to improve the communication and collaboration tools inside the CVE virtual environment and the SCI development environment. Collecting data is achieved by both: (1) participants' responses to the survey, and (2) observing interactions among the students/players from inside the CVE virtual environment.

C. *Hypothesis*

The hypothesis claims that "The virtual environment provides the collaborative development environment with the online presence and awareness information that increases use and usefulness of collaboration tools. Next section includes an evaluation study to test the correctness of this hypothesis.

IV. METHODOLOGY: EVALUATING 3D WORLD INTEGRATION

Team members need to evaluate each other, determine who has what knowledge, and who they can ask for help on specific technical topics. In an environment such as SCI, team members need to feel that they belong to the team, and need to feel the other team members' presence in order to achieve their goals [13].

The hypothesis suggests that if improving distributed teams' collaborative-effort requires more social contact, contact in a 3D virtual environment might provide it. This discussion is supported both by literature [14], [15], [16] as well as observation of multiplayer online games like World of Warcraft and virtual worlds like Second Life. In such environments, users who never meet face-to-face are able to meet, form groups and make plans to perform complex tasks within the virtual world. This creates a belief that distributed development could be improved using such worlds, either in the communication or the development environment.

Validating the hypothesis was achieved by testing the effectiveness of the virtual world and the avatar presence in increasing the sense of belonging to the group, and to what degree developers feel socially present, and perceive each other as real in virtual interactions.

In this section the presence and feeling of belonging was tested using both subjective and behavioral measures. Depending on the subjective nature of the presence [17], it was logical to measure presence relying on the SCI system users' self-reported sense of belonging. Measuring the subjective feeling of presence in such an environment is done by conducting surveys and questionnaires on the system users.

To help mitigate the subjective nature of the questionnaire, this article used another approach which is a behavioral measure. The belongingness was tested by measuring the users' responses and interactions that were produced automatically while using the system, and related to being present in the environment.

The major classes of interaction in collaborative virtual environments are navigation, selection, manipulation, system commands and symbolic input [18]. In order to validate the suggested hypothesis, some responses (interactions) were examined as a possible measure of presence; the interactions used are mainly *navigation, selection, system commands, and symbolic input* such as : changing location and moving between the environment rooms (navigation), using the teleport from inside the 3D to move between different projects' virtual rooms (navigation), opening/closing a room door (selection), clicking an avatar or sending a greeting (selection and symbolic input), viewing a summary of projects' users and accessing others' history from inside the 3D (system commands). The premise is that the more users repeat the process, the more they were demonstrating a sense of belonging in the 3 D environment, and the more real the environment was to them.

Usability

Experience from many different projects has shown that different people encounter different usability problems. Therefore, it is possible to improve the effectiveness of the tools significantly by involving multiple participants. Evaluating usability is an important factor to the success of the software development, and to ignore evaluation is to risk failure. Evaluating the 3D environment usability can include metrics. Bowman et al. [18] categorizes metrics as:

- Task performance metrics such as speed and accuracy.
- System performance metrics. A major example is the latency issues that affect the user's experience while collaborating.
- User preference metrics.

For the purpose of this study, user preference metrics were used. These metrics refer to subjective awareness and immersion of the system by the user, such as the ease of use, ease of learning, and support functionality that are highly valued by the participants/users [19]. Such issues that are correlated with subjects' perception were commonly evaluated with questionnaires that indicate the user's experiences of presence and user's comfort issues as an example.

A. *Experiment*

The study is focused around performing social activities related to the 3D world. This Section presents a discussion of the data collected during the study.

B. *Results*

After performing the experiments, the collected data were subjected to qualitative and quantitative analyses. Qualitative analysis describes the data that has been obtained through questionnaires and surveys. Quantitative analysis describes and compares numeric data collected by the system log files. This section describes both of the qualitative and quantitative results.

Qualitative Analysis: After finishing the task, the participants were given a survey to complete and return anonymously. The bar graph in Figure I corresponds Qualitative Analysis: After finishing the task, the participants were given a survey to complete and return anonymously.

The bar graph in Figure 1 corresponds to the answers of 3D related statements that were asked in the survey.

1. I have had experience in using 3D virtual environments before the session.
2. The 3D world brings a real world value to the collaboration.
3. The use of 3D virtual environment and avatars creates a sense of presence of others.
4. Having visual representation of others inside the 3 D world is sufficient to create a high sense of presence.
5. Interaction and collaboration is needed to create a high sense of presence.
6. The sense of my teammate's presence increased with the interaction and collaboration inside the 3D world.
7. In a virtual environment, you can see other people's avatar moving around, and you can see what they are doing. Do you think that helps you to interact and be more social than if it would be chat-only or web-based environment?

It was observed from the data shown in Figure I that only 50% of the participants had experience in using a 3 D virtual environment before the session. All the participants agreed that the 3D world brings a real world value to the collaboration. Also, they expressed that the use of 3D worlds and avatars made them feel a sense of others' presence in the environment. 75% of the responses indicate that having the avatars visual representation within the 3D world was enough to make them feel the presence of their teammates. The responses showed that the interaction and collaboration within the 3D world were important factors to create the feeling of belongingness between the teammates, and that their sense of presence increase by the interaction and collaboration. They also expressed the usability of the 3D interactions and that it helps the interaction and socializing more than face-to-face interactions.

The bar graph in Figure II corresponds to the answers of the following statements:

8. The CVE environment improved my team productivity, and made the task enjoyable.
9. I find CVE easy to learn.
10. I find CVE to be a useful environment.
11. Rate your satisfaction with the collaboration outcome.
12. Rate your satisfaction with the collaboration process.
13. Other than the instability of the CVE server software,
    (13-1) The supported communication and collaboration tools are enough to provide a productive environment.
    (13-2) The supported awareness and presence information is enough and adequate.
    (13-3) Rate your willingness/motivation to use the SCI environment for collaboration tasks again.

The data collected from the above statements responses showed the usefulness and usability of the SCI development environment. All participants agreed that the CVE is useful

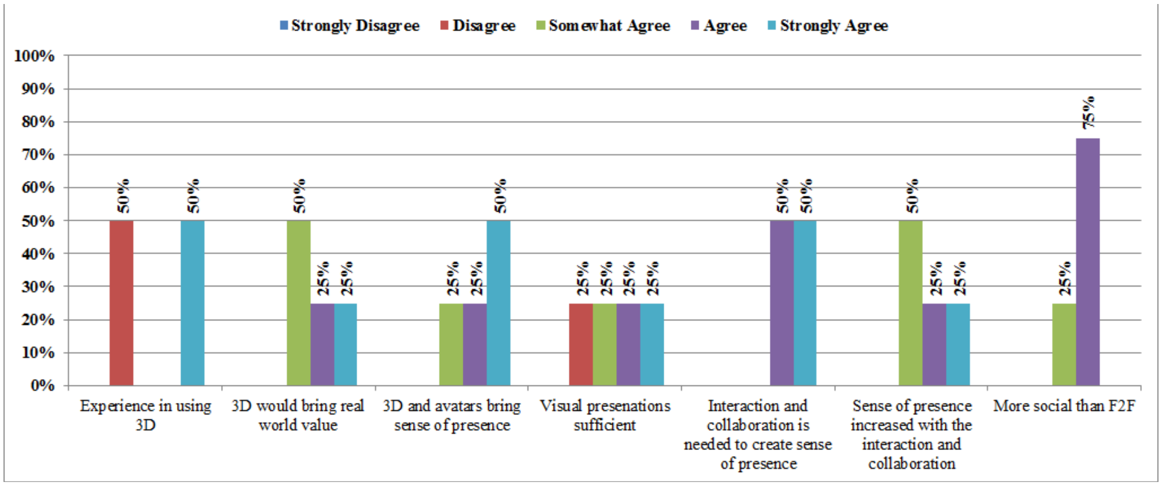

Figure I. 3D Related Statement's Responses.

and easy to learn. 75% of the respondents expressed satisfaction of both the collaboration process and outcome, and claimed that the environment helped to increase their team productivity and made the task more enjoyable. 75% of the participants found the integrated features (communication and collaboration tools, awareness, presence, and social network features) were enough and adequate. The bar graph in Figure III corresponds to the answers of the following statements:

- (14-1) I find that CVE is a suitable classroom programming environment?
- (14-2) I am willing / motivated to use the SCI environment for collaboration tasks again?

The responses showed that 75% of the participants showed satisfaction and agreed that SCI is a suitable classroom environment. 50% of the participants found SCI enjoyable, and expressed willingness to use it again for collaboration tasks. On the other hand, 50% expressed unwillingness to use it again, and that is very probably related to server instability. Also they found difficulty in using text chat for participants who do not type fast, and suggested to integrate a voice chat system.

V. QUANTITATIVE RESULTS

Comparing the numeric data obtained from the log files collected by the system during the tasks, it appeared that the participants were immersed in the 3D world, and they spent time wandering inside the 3D environment. The data in Table II shows a list of the interactions the participants made while in the 3D world. These interactions include: *changing locations, viewing activities, viewing changes history, teleporting to different rooms, and greeting other users.*

The data from Table II showed that the participants changed their location inside the 3D and that they were immersed in the environment. They tried to teleport from room to room, and interacted with others avatars by: sending greetings, checking their history, and view their activities. Table III shows a summary of these interactions.

TABLE II. 3D INTERACTIONS STATISTICS.

Interaction	Times Occurred
Greetings	12
Door Open/Close	108
Teleport	64
Change Location	909
View Activity	3
View History	7

TABLE III. 3D INTERACTIONS STATISTICS.

	Navigation	Selection	System Commands	Symbolic Input
Times Occurred	*973*	*108*	*10*	*12*
Percentage (%)	88%	10%	1%	1%

Also it appeared that 65% of the total interactions were interaction occurred between projects' partners, groups' partners, and friends, and 63% of the total communications that occurred between the participants were initiated by text chat.

VI. CONCLUSION

The presented experiment aimed to get results to the question of whether 3D virtual environments can add real value to the SCI environment and online collaboration. In spite of a noticeable effect of the 3D integration, the instability of the CVE server software had a negative impact on the results of the 3D CVE participants' responses, satisfaction, motivation or willingness to use the CVE.

Our hypothesis that the 3D world integration, being virtually embodied in a configurable 3D collaborative environment, provides the collaborative IDE with online presence, and increases the usability and usefulness of the collaborative tools was confirmed by the groups study survey responses, and the data collected from the system log files.

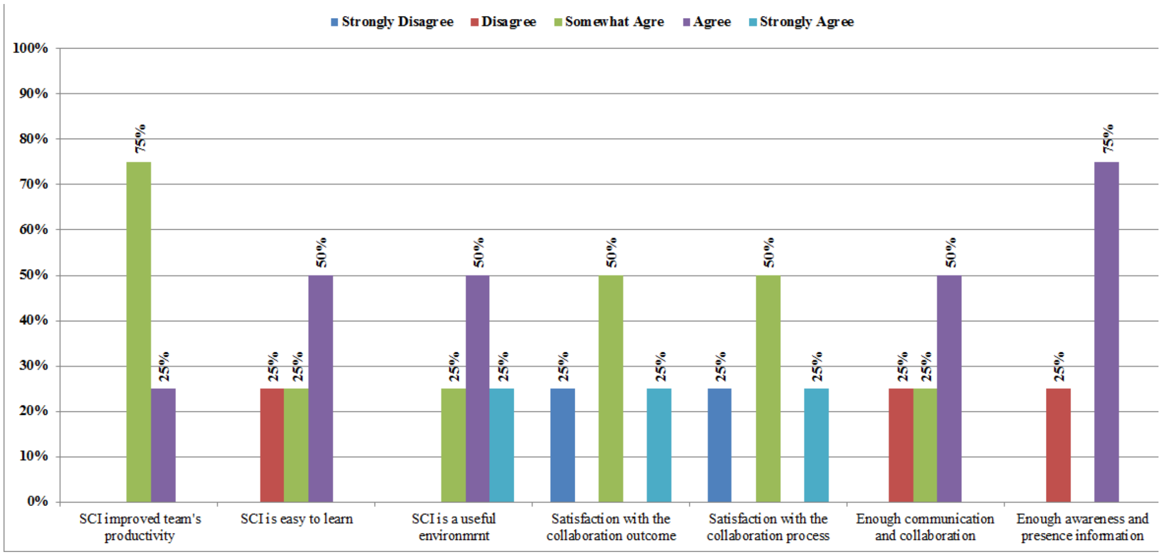

Figure II. General Related Statement's Responses.

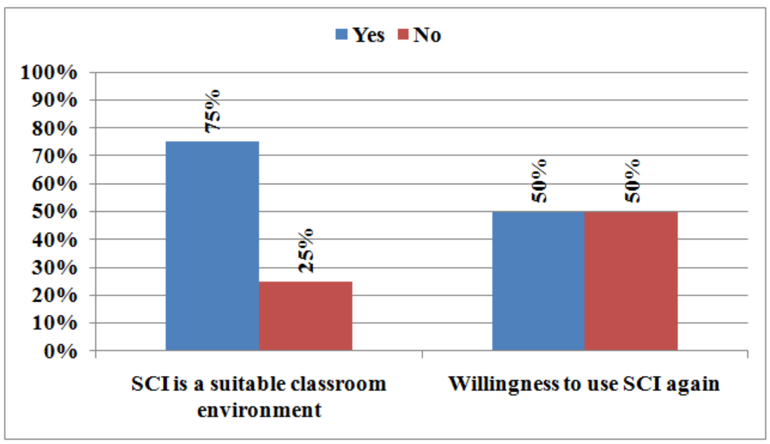

Figure III. General Related Statement's Responses.

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