Virtual Worlds: do we really need the third dimension to support collaborative learning?

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***Abstract*— The goal of Computer Supported Collaborative Learning (CSCL) is to enable students to work together, to emphasize and verify their knowledge by reciprocally interacting, and to reinforce their social dimension.**

Virtual Worlds provide several features to support informal communication and to create communities. They have been adopted by many universities and organizations to support distance learning.

In this paper we report on an empirical study that assessed the value added by a Second Life based meeting system to a collaborative learning activity, as compared to a meeting system based on synchronous text-based communication. The experiment results show that the adoption of a 3D virtual environment does not either improve the perceived level of comfort with communication or introduce distraction during the activity, whereas the user perception of the feature offered is positive.

***Index Terms*— Virtual Worlds evaluation, Second Life, collaborative learning, CSCL.**

I. INTRODUCTION

Today, Computer Supported Collaborative Learning (CSCL) technologies often rely on electronic synchronous and asynchronous media. In this scenarios, learning experiences are often conducted using synthetic environments and it is easy to foresee a future increased adoption and new stimulating settings for distance learning and communication in general.

Collaborative Virtual Environments (CVEs) are a CSCL communication mechanism used to collaborate. They offer the possibility to simulate the real world as it is or to create new imaginary worlds. Interacting with these environments, people can actively experiment situations that are useful for understanding concepts as well as learning to accomplish specific tasks [6].

The metaphor of 3D collaborative virtual meeting rooms is exploited by several tools, such as [5][15][19][21][24]. All these tools represent human participants via avatars. In [11] a Second Life (SL) virtual environment supporting the control and setup of collaborative learning activities has been proposed.

Several authors, such as [12][17], and organizations, such as [27], affirm that 3D web Virtual Worlds may really represent a likely hypothesis on the future of the web and it can be easily foreseen how the evolution of web exploration scenarios and interaction metaphors will go towards more natural real world practices and attitudes.

As a confirmation of this recent interest of Academia and not only, for the chances offered by virtual worlds to collaboration, Lindeman et al. in [16], report about the use of SL for the yearly cycle of a program committee meetings (IEEE Virtual Reality 2009). They conclude that SL is a viable alternative to face-to-face, it's feasible to run a meeting in SL and avoids the time and money associated with face-to-face.

Virtual Worlds such as Active Worlds [1], Croquet [7], Second Life (SL) [22] and There , propose environments which are quite diverse, ranging from replicas of real universities to other planets, or completely fantastic.

The interaction patterns proposed by virtual worlds are typical of video games and web community. Considering that future users are today's 'digital natives', that is they are growing up in a technological environment, such as multi-player online games and instant messaging, it will be natural and pleasant for them to use a virtual world for collaborating.

SL is based on the archipelago metaphor, where islands are connected to each other via teleportation links, bridges and roads. Islands are populated by user avatars and host various types of artifacts, ranging from big complete buildings to small fashion accessories [12]. The SL environment enables to construct 3D objects and provides a scripting language LSL [11] for developing active behaviors.

3D Virtual Worlds are typically characterized by three relevant features: the user perception of the 3-D space, the avatar that visually represents a user and an interactive communication media, useful to support social connections [10]. Usually Virtual Worlds are suitable to support heavily communication based actions, offering to users textual or voice chats, and providing several forms of content and interaction. Our main research question is whether these features offer an effective added value to collaborative learning activity.

Many experimental studies have been conducted for assessing how rich interaction based on audio/video technology differs from lean interaction based on single text-based channel. Despite the negative premises of computer-mediated communication theories, the use of text-based communication has been found to be useful for remote group collaboration, as in the case of eliciting and negotiating software requirements [8],[9]. For example, text-based collaboration has been found to improve specific communication aspects, such as the comfort with communication preceived by stakelholders (e.g., lower peer-pressure) [3].

In [2] it has been proved that specific collaborative settings exist, characterized by reduced information loads, where synchronous, text-based communication was adequate to achieve a common ground among conversational participants unknown to each other.

In this paper we assess the added value provided by a Second Life based CSCL system, during a collaborative learning activity, as compared to a meeting system based on synchronous text-based communication. Particular attention has been devoted to verify that a richer environment does not introduce distraction factors that could affect the learning.

II. TECHNOLOGICAL OVERVIEW

To evaluate the efficacy of a virtual environment in supporting collaborative learning with respect to a pure textual approach, we selected the two systems briefly described in the following.

A. *eConference*

This system is a text-based conferencing tool that has been developed at the University of Bari as part of a broader research effort with the aim to support the interaction of ad hoc, goal-oriented workgroups, which need low-cost administration infrastructure just to complete the task at hand [4]. It enables the meeting leaders to define the roles of the participants and provides each role with the appropriate view. It also offers a closed group chat with an agenda, whiteboarding, meeting minutes editing and typing awareness capabilities and helps organizers to set up a meeting and to control discussions.

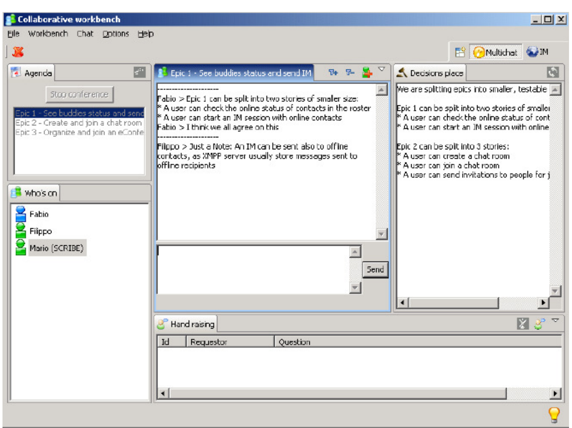

Figure 1 The eConference tool

The tool windows is organized in six main areas: the agenda, the input panel, the message board, the hand raising panel, the edit panel, and the presence panel (see Fig. 1). The agenda indicates the status of the meeting, as well as the current item under discussion. The input panel enables participants to type and send statements during the discussion. The message board is the area where the meeting discussion takes place. The hand raising panel is used to enable turn-based discussions. The edit panel displays a summary of the discussion. The presence panel shows which participants are currently logged in and the role they ere palaying. Finally, the hand raise panel mimics the hand raise social protocol that people use during real meetings to coordinate discussion and turn-taking.The hand raise feature of eConference also gives to the moderator the ability to preview queued questions.

eConference has been used at the University of Victoria, Canada, to run a controlled experiment on the comparison between co-located and synchronous text-based interaction, in the context of distributed requirements engineering [3].

B. *SLMeeting*

During the last two years the Mathematics and Informatics Department of the University of Salerno has engaged several didactic experiments adopting SL to embed the distance learning activities. In [10] we presented a Virtual Campus, named SecondDMI [24], created using Second Life. We evaluated the perceived sociality of the proposed environment and results suggested that it facilitates the perception of social spaces with attributes as trust and belonging. Also a deep sense of community is perceived, in general. SecondDMI has also been equipped with a collaborative learning environment, presented in [11], named SLMeeting, to enhance SL with meeting floor control and management features.

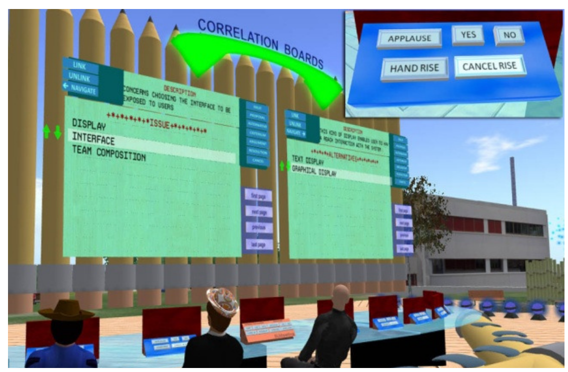

Figure 2 A synchronous distance learning action at SecondDMI

In particular, a collaborative learning activity requires several preliminary phases: the delivery of the material to the students, the role assignment, the communication of the activity start time, date and location. Also the session closure has to be supported.

This environment enables to control the meeting through interactive ad-hoc developed SL objects. Each student uses this space to synchronously work with the other members of the team. An example of collaborative setting is shown in Figure 2. A student is selected as leader of the group: he/she seats in the center of the table, at the leader control bar, and his/her avatar wears the leader shirt. Gesture bars, as the one shown in Figure 2, facilitate non-verbal communication and contribute to reduce distraction. As an example, the hand-rise button enables students to book their interventions, which are scheduled and displayed on a booking list blackboard. The final goal is to build the needed knowledge to enable each student to report on a subject determined by the teacher.

We remind that in SL it is not possible to save the conversations: as a consequence, workspace awareness, shortly resumed as "How did it happen?", is not supported. This feature has been integrated in SLMeeting by an ad-hoc Moodle plug-in useful to record the knowledge created by the students using the chat, to provide all the information concerning the event and to enable the teacher to set-up the collaborative session. The result of the integration between SL and the Moodle plug-in is a system that naturally enriches SL environments with LMS services and synchronous collaborative learning.

Finally, it is important to point out that the system, even if in a 3D environment, provides users with information displayed by textual boards.

III. THE EMPIRICAL STUDY

A collaborative session has been organized as a controlled experiment aiming at assessing the use of the proposed SL collaborative learning approach as compared to a meeting held via a text-based conferencing system. The participants were students of the advanced Software Engineering course at the University of Salerno. The controlled experiment has been performed following the template suggested by Wohlin et al. [26].

A. *Experiment definition and context*

A collaborative learning activity performed by small teams using the selected tools has been experimented on 26 students, who volunteered to take part in the experimentation. A pre-experiment questionnaire has been proposed to them to assess their background in using

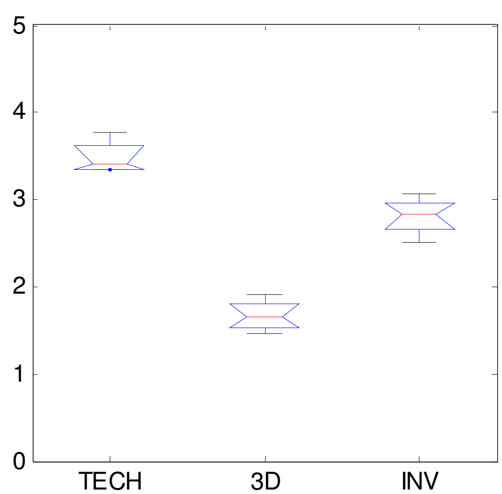

Figure 3 The pre-experiment questionnaire: results

computer for communicating (TECH), videogames and 3D applications (3D) and their involvement attitude (INV). The data collected during the pre-experiment questionnaire on the subject background are summarized in Figure 3. The answers to the survey questionnaire have been evaluated on a five-point Likert scale, anchored with values 1=very low and 5=very high [20]. Figure 3 depicts the user skill background, in terms of technological (both PC and 3D) capabilities and attitude to be involved.

To harmonize the 3D experience among the participants, the novice SL players received a quick training before the evaluation started. In addition both the systems were presented to the subjects. After the training session the students were randomly grouped in four teams, two composed of seven subjects, the others of six.

The experiment has been performed online at the University of Salerno in the Software Engineering laboratory. The sense of "presence" and "awareness" are inherently perceived as much stronger in a 3D environment than in a two-dimensional chat. Hence, we decided to investigate the difference between TXT and SL collaborative learning to verify if there exist some advantages in using 3D environments respect to 2D chats in case of collaborative activity based on negoziation.

The selected tasks that the subjects had to perform required to infer a property starting from a set of rules. The solution had to be the product of a collective discussion because each group had to provide a unique result. Each task was expected to be accomplished within one hour.

In particular, the task T1 is a riddle proposed by Einstein, who said that 98% of people in the world cannot solve it [13]. The task T2 is a riddle comparable in terms of difficulty. The common characteristic of the selected tasks is that there is a need of collaboration and discussion to reach a solution.

Two different didactic modalities, namely TXT (collaboration using eConference) and SL (collaboration using SLMeeting), are used to perform the group collaborative sessions.

Both methods were applied to both the tasks.

B. *Design*

In order to properly compare SL and TXT didactic modalities and analyze the results, we considered only two independent variables, namely *method* (levels SL and TXT) and *task* (levels T1 and T2)

TABLE I. THE EXPERIMENT DESIGN

Groups			
A	**B**	**C**	**D**
T1_SL	*T1_TXT*	*T2_SL*	*T2_TXT*
T2_TXT	*T2_SL*	*T1_TXT*	*T1_SL*

To compare the selected technologies, we considered as dependent variable the score obtained by questionnaires filled after both SL and TXT lab sessions and after the whole experiment.

All combinations of the factors, Method (SL and TXT) and Task (T1 and T2), have been considered when designing the experiment. To avoid results to be biased by task difficulty, group ability and learning effect, all possible permutations of TXT or SL treatment, and task ordering were experimented by one group. Table I summarizes the design of the experiments, where *Ti_Mi* indicates the combination of task and method performed by teams in a laboratory session.

We randomly assigned members to the groups A, B, C, and D.

C. Preparation

The subjects attended an introductory lesson presenting the SLMeeting and the eConference systems. This training session aimed at providing all the subjects with sufficient prior knowledge on the usage of the two collaborative tools. The training sessions were concluded presenting detailed instructions on the tasks to be performed.

At the end of each laboratory session the same survey questionnaire, shown in Table II, has been proposed to the subjects. To summarize the impact of communication modalities on collaborative learning through the subjects' perception, we conceptualized three constructs [3][11], namely involvement - INV, comfort with communication mode - COM, material and environment organization - ORG.

TABLE II. THE POST-TASK QUESTIONNAIRE

	Question	Construct
Q1	I had enough time to perform the required activity	ORG
Q2	The activity objectives were clear to me	ORG
Q3	The activity to perform was enough clear to me	ORG
Q4	The material I received was enough to perform the activity	ORG
Q5	The task to perform was easy	ORG
Q6	Communicate with the other participants was easy	COM
Q7	The opportunity to participate in the discussion was adequate	INV
Q8	I actively participate to the experience	INV
Q9	I have been encouraged to discuss contrasting solutions with the other group participants	COM
Q10	The other participants adequately answered to my communications	COM
Q11	I felt myself involved during the experience	INV
Q12	While I performed the activity I had the sensation to lose time	INV
Q13	It has been easy to reach a common decision inside my group	COM
Q14	The information on the screen where disposed in a logical way	
Q15	If I can, I will regularly use this didactical approach in the future	
Q16	My global impression is positive	

The ORG category has to be considered as a control factor because these questions have been added to easily verify if a wrong organization of the experiment has been conducted, then invalidating the outcomes.

The last three questions of the Post Task Questionnaire have been formulated to assess the interfaces and to have a quick resuming impression on each system.

At the end of both tasks, each subject has to fill in the questionnaire reported in Table III, containing some additional evaluations which contribute to assess a direct comparison between the two approaches.

The answers to the questions of the two survey questionnaires are based again on the same five-point Likert scale.

TABLE III. THE POST-EXPERIMENT QUESTIONNAIRE ADDENDUM

	Question	Construct
Q17	Participants' avatars were an adequate representation of human being	AVA
Q18	The virtual environment design was stimulating	CVE
Q19	It was easy to distinguish the participants' avatars	AVA
Q20	I was aware of the existence of my avatar	AWN
Q21	It was easy to control my avatar	DF
Q22	I had few distraction using SLMeeting	DF
Q23	I had few distraction using eConference	DF
Q24	Non verbal communication (gesture) facilitated my interaction with the others	COM
Q25	Non verbal communication has originated distraction	DF
Q26	Group activity has had benefit from the virtual environment	COM
Q27	Group activity has had benefit from the textual environment	COM
Q28	I think that the added value of the virtual environment is	CVE
Q29	If I should choose a meeting environment I will prefer SLMeeting	
Q30	If I should choose a meeting environment I will prefer eConference	

D. Material and execution

The teams accomplished each laboratory session of the experiment in one hour. To perform the experiments each subject was provided with the following needed material:

1. the introductory lecture slides provided in paper format (TXT) or pre-charged on the Slide Presenter (SL);
2. the guidelines to perform the assigned tasks;
3. the problems to be collaboratively solved in the two tasks, in paper format (TXT) or pre-charged on the Slide Presenter (SL);
4. the report forms to be adopted for reporting the results;
5. the survey questionnaires to be filled in at the end of each laboratory session.
6. the Post Experiment Questionnaire Addendum to be filled before closing the experiment.

IV. EVALUATION

The two Post Task questionnaire results let us compare the SL and EC environments by evaluating the user perceptions collected during the experiment. Figure 4 aggregates in three constructs the user answers: their sense of involvement in the experience (INV), the quality and the support provided to the communication (COM) and the organization of the experiment (ORG). In particular, the upper part of the picture depicts the SLMeeting results while the lower one resumes the eConference performances.

In a text based communication context, both technologies seem to be perceived in the same manner. We point out a different dispersion for the COM category which reveals user opinions about communication support of SLMeeting to be a little more various than the opinions on the eConference environment.

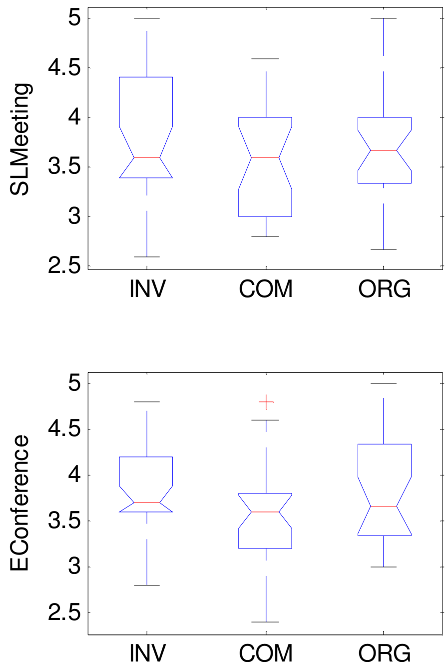

Figure 4 The Post-Experiment questionnaire: results

In the Post-Experiment questionnaire addendum we formulated three pairs of questions aiming at directly evaluating the possible interferences that a 3D environment may add to usual communication channels like textual chats. Indeed, The eConference environment tends to concentrate user actions on communication and meeting flow, while SLMeeting leaves the users free to choose their own view on the action. The proposed experiment aimed at checking that this freedom, in particular with novice users, and when they are immersed in an environment richer than strictly needed, may disrupt their attention.

The first pair of questions are Q22 and Q23, that provided us the data to evaluate if SLMeeting, and in general the SL environment, introduce disruption elements in an environment that needs only textual information. The questions are focused on distraction and may be connected with the sequent hypothesis test:

H_0: SLMeeting does not add disruption elements respect to eConference

H_1: SLMeeting adds disruption elements respect to eConference

The result obtained from a paired t-test run (p-value = 0,955) does not allow us to reject H_0.

Questions Q26 and Q27 aim at directly comparing the communication support provided by the two environments.

Also in this case we can formulate two hypotheses:

H_0: SLMeeting does not lack in group communication support as compared to eConference

H_1: SLMeeting lacks in group communication support as compared to eConference

Also in this case, the t-test (p-value = 0,900) does not provide evidence to abandon the null hypothesis H_0.

Figure 5 resumes the individual differences between SLMeeting and eConference scores and provides an

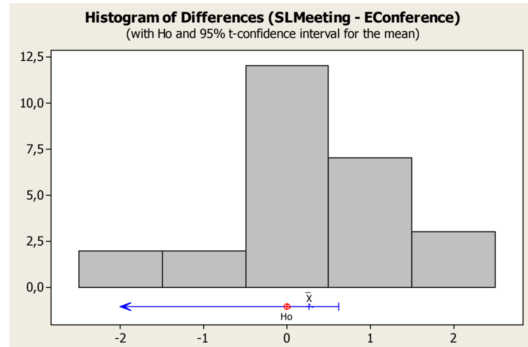

Figure 5 The histogram of the differences perceived by users and evaluated by questions Q26 and Q27.

interval estimation for the mean. The depicted histogram reveals little better perceptions reached by SLMeeting compared to eConference in terms of provided group support.

Future intentions to use one of these collaborative systems are checked by the Q29 and Q30 questions (*If I should choose a meeting environment I will prefer SLMeeting/ I will prefer eConference*). Also in this case there is no statistical evidence of the user preferences between SLMeeting or eConference, even if the sample mean and median reveal a little higher scoring of 3D technology.

It is important to point out that we checked the Normal distribution of questionnaire result data by Kolmogorov-Smirnov tests before running each paired t-test.

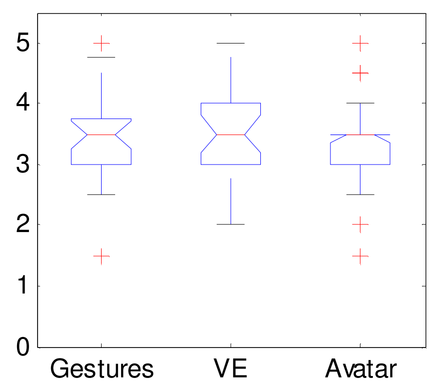

Figure 6 User perceptions after the whole experiment

We addressed questions Q17, Q19 and Q21 (Avatar) to the evaluation of avatar user perception in terms of their representativeness, social awareness and easiness of control. Questions Q18 and Q28 (VE) are specific for evaluating the proposed virtual environment and its added value to the collaborative learning experience. Q24 and Q25 address the value gesture add to textual communication. Question Q25 scores have been reversed before aggregation. As depicted in Figure 6, the results reveal a good perception of gestures and their use during learning collaboration activities, a good impression about the 3D environment and its usage and a diffuse sense of identification of users with their synthetic representatives.

An analysis of the chat logs revealed that the number of exchanged messages among the group members has not affected by the selected technology. Similar considerations also hold for the completion times of each tasks.

V. CONCLUSION

In this paper we report about an empirical study aiming at assessing the value added by a 3D virtual environment to a collaborative learning activity with respect to a meeting system based on synchronous text-based communication.

This research is the complementary view of an empirical study conducted in [11], where the use of the proposed SL collaborative learning has been compared with face-to-face group collaboration. In particular, the differences between the two didactical settings in terms of performances, comfort with communication mode, involvement, and global satisfaction have been compared. Previous results suggest that SL seems to be an effective customizable delivery environment which can be adopted as an alternative to a real world collaboration.

The experiment results described in this paper revealed that the 3D environment does not add disruption elements with respect to the specialized text-based conferencing system. In a technological landscape that seems to bring web browsing and community interaction in a 3D context, if the third dimension does not interfere with the normal communication and does not distract participants, it seems natural to adopt a richer environment. Indeed, collaborative learning can be a specific task to perform in a larger variety of activities conducted in a virtual campus, such as synchronous distance lectures, socialization activities, virtual laboratory, serious game and others. This pool of activities enforces the perception of belonging to a community and of the situation awareness of participants.

Thus, we are finally ready to answer to the question: “do we really need the third dimension ?” with an encouraging “Why not ?”.

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