SLMeetingRoom: A Model of Environment to Remote Support Meetings, Oriented Tasks with Small Groups for Second Life

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***Abstract* - 3D virtual worlds are typically designed to reproduce the physical world, both in the features of the meeting place and also in how people interact with each other. We try to get a better understanding of technical and behavioral issues found in different meeting environments designed for collaborative work. From the problems that we have found, we proposed the SLMeetingRoom, as a model of environment for work meetings which is composed of a set of components to support basic working activities in Second Life. We also performed a pilot study under four different conditions of communication: face-to-face, videoconference, Second Life without the SLMeetingRoom and Second Life with the SLMeetingRoom. The pilot study pointed out that the SLMeetingRoom model is a promising environment according to the criteria: cognitive effort and sense of presence, however, for tasks completeness and participation level, we could not find statistical evidence to support our research hypotheses.**

Keywords - 3D virtual worlds, collaborative work, distributed meetings, Second Life, SLMeetingRoom.

I. INTRODUCTION

With the emergence of Web 3.0, the 3D virtual environments are gradually becoming more common as everyday tools [1], and as tools for holding meetings [1][2][3]. The most popular of them is Second Life, a 3D virtual environment simulation, used by thousands of users simultaneously, via interactions between their virtual characters, called avatars [4]. According to Olivier and Pinkwart [1], Second Life covers the most important aspects for synchronous communication, so important in the area of CSCW, such as perception and support for remote synchronous collaboration, allowing the Second Life to extend the limits of remote interaction through 3D models that offer huge potential for new forms of human interaction, cooperation and socialization.

The problem addressed in this paper is that 3D virtual environments like Second Life do not support basic activities for the conduction task-oriented, remote and scheduled, meetings for small remote and non-anonymous groups.

Second Life has a great potential to support collaborative work, mainly because it offers immersion to the participants, but on the other hand, it is not an environment which is designed to support the basic activities to perform meetings.

The main hypothesis of this paper is that if we enrich the Second Life, providing an environment model with a set of essential components to support remote meetings, scheduled and task-oriented, with small groups, remotes and non-anonymous, we may get results closer to the face-to-face, i.e., the task performance degree, group participation, cognitive effort and sense of presence, will be closer to face-to-face group ("gold standard") than groups using the traditional videoconference systems and Second Life without any tools for support meetings.

Thus, we propose to create an environment model to support the basic activities of meetings, called SLMeetingRoom. The SLMeetingRoom constitutes a meeting room in Second Life, a 3D virtual environment, and is composed of the following components: whiteboard, agenda, task tracking schedule, information repository, model of argumentation, Social Proxy, voting, gestures panel, stopwatch and presence list.

Thus, we seek to understand what happens in remote meetings using the technology of 3D virtual environments, and how to support work meetings mediated by these environments, as well as the participants' behavior while using the environment.

II. RELATED WORK

The tendency of people to come together and form groups is inherent in the structure of today's society. When a group is given a task, there are many ways that they can follow to accomplish this task [5]. One of these ways of working is the meeting which gathers a group of people to communicate and interact together to achieve common goals and objectives [2][6].

According to [2], meetings are the only effective mechanism that allows for problem solving and consensus building. A meeting can be classified as face-to-face or remote (distributed), planned (scheduled in advance) or unscheduled (occurring spontaneously) [7][8]. Another kind of meeting is the task-oriented, usually held in small groups in order to generate results at the end of each section. A task-oriented

meeting sets goals, analyzes information, identifies and solves problems, makes decisions and plans future actions [9].

With the technological growth and the advent of Internet, computers have become excellent tools to support activities that are traditionally conducted by persons. The use of computers to support collaborative work led to the area known as CSCW (Computer Supported Cooperative Work) that aims to understand how the technology acts in the execution of tasks and work together, covering the computational support to activities that involve more than a person [8].

When people work together in physical meetings, they can see the benefits of the common workspace, and this fact changes the performance and the language used by them. Most people have the face-to-face meetings as the ideal form of communication, regarded by many as the "gold standard" for group interaction [10][11][12]. In face-to-face meetings the participants may explore human senses such as the tone of voice, gaze, postures, gestures, etc. to obtain and transmit information in a natural way [13].

Olson [11] reported some advantages of working in the same place, such as increased learning, motivation, coordination and productivity. But there are also some problems such as: high costs associated to the time and the space allocation [14], excessive attention to minor issues, apprehension feelings about how the ideas will be received by others [6], difficulties in exposition of ideas and eloquence, nervousness etc. [14], and this often generates less participation in the meetings [6].

The video-mediated communication has been identified as a substitute for face-to-face communication. Current videoconference systems have become a very attractive option due to the ease of communication and high level of participation [15], as well as cost reduction with physical displacement and subtle signal transmission [10]. On the other hand, videoconference is considered an invasive solution [16], with high cost of acquisition [10] and does not allow the configuration of a real context of a meeting room with remote participants acting seated at a table work [17]. Results show that the arrangement of seats in a remote meeting has an important impact in the talks mediated by video, as differences in speech patterns, sense of unity and quality of solutions [17].

However, with the emergence of Web 3.0 and 3D virtual environments, new opportunities for virtual meetings have been proposed [1][2][3]. Among the available 3D virtual environments for social interaction and communication, we found the Second Life [4], as the most popular among existing environments.

The immersion of the participant is the strong point of Second Life [18]. Second Life creates the feeling of co-location and it simulates the sensation of being physically co-located. Thus, we have an environment that is favorable to conduct work meetings extracting advantages from face-to-face and remote meetings.

Companies like IBM, Intel, and NASA use Second Life for virtual meetings between employees, affiliates and clients, reducing the cost of space allocation and travel time [2][4]. The academic community uses it as an educational tool [19][20][21]. Researchers are betting on the possibility of developing a professional attitude within these environments [12]. These factors justify the choice of Second Life as our research object, because according to Olivier and Pinkwart [1], Second Life has proven to be a 3D virtual environment that enhances remote synchronous collaboration at the level of co-located, as effective as a group meeting in real life. These features make Second Life a competitive environment, compared to the existing ones, opening opportunities for research topics.

III. SLMeetingRoom Model

The SLMeetingRoom model is a working group model for meetings whose participants are geographically distributed. The model is composed by 10 components: (1) Whiteboard: allows exposition of ideas and opinions on the subject that is being discussed; (2) Schedule: integrates the group, combining the agenda of the participant with the agenda of the group; (3) Task tracking schedule: allows participants to follow up future tasks, their respective executors and deadlines to be met by a particular participant; (4) Information repository: allows the participants to access to the meetings documents; (5) Model of argumentation: structures the discussion through a system of questions, answers and arguments; (6) Social Proxy: provides visual feedback about the presence and activities of the participants during the meetings; (7) Voting: allows participants to vote anonymously and individually in a specific subject under discussion; (8) Gestures panel: provides a basic set of possible gestures used during a meeting; (9) Presence list: registers the presence of the participants; (10) Stopwatch: indicates the remaining time to the meeting participants.

To design the SLMeetingRoom model we brought inspiration from the representation models of distributed systems arranged in layers. The layers represent services provided by the model. All users who enter the meeting room, supported by SLMeetingRoom model, they have access to all layers. The components act as service providers in the layers, and can operate on several layers at once. Figure 1 presents the model and its layers for supporting the meeting process.

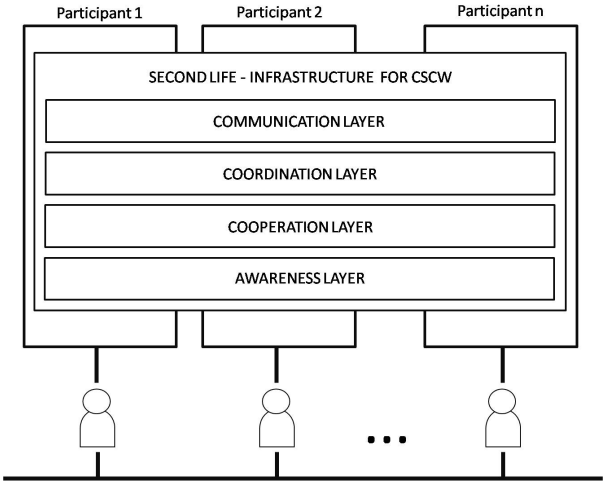

Figure 1. SLMeetingRoom Model.

When people act in a working group is important to communicate, cooperate, divide and coordinate tasks, namely the group's success depends on the individual action of each participant. Second Life is the most external layer of the model. It provides the infrastructure of a distributed system for supporting the meeting process by creating a shared space for group interaction.

Thus, the communication layer aims to improve SL native communication providing components such as panel gestures, meeting agenda, the ballot box, repository of minutes and whiteboard. The coordination layer was created to give support to the working group coordination, considering that Second Life does not have features that allow the coordination of tasks. In this layer we provided components such as: meeting agenda, schedule, stopwatch and presence list.

The layer of native Second Life cooperation was enhanced with whiteboard, the information repository and model of argumentation, components that put the focus on shared operations. Finally the layer of perception, that is intended to provide feedback about what is happening and what the participants are doing, has components such as panel gestures, stopwatch, schedule, presence list and Social Proxy.

As in layered distributed systems, there is a relationship of dependency among the layers, for example, the communication layer generates commitments to coordination, good coordination facilitates cooperation activities, the perception supports the communication and coordination. Each layer is separated for analysis, but they act in an integrated way during group work.

IV. METHODOLOGY

In order to accomplish our objectives, we have first performed a pilot study with real users that did task-oriented work meetings. The methodology can be characterized as a comparative experimental study which focused mainly on activities involving the process of holding distributed, task-oriented meetings and not the final generated product.

A pilot study was carried with groups working together in four different environments (face-to-face, videoconference, Second Life without the SLMeetingRoom and Second Life with the SLMeetingRoom). For each one of the environments, 4 work meetings were held, resulting in a total of 16 meetings.

A. Participants

The users' participation was voluntary, without any reward or prize. Participants in this pilot study were twelve Computer Science master students at Fluminense Federal University (UFF) enrolled in the Interface and Multimedia Course. Participation in the experiment was one of the requirements for the conclusion of the discipline, as revised and approved by its lecturer. The members of the groups knew each other, but they had never worked together.

B. Experimental Task

The task of the pilot study was designing a Web interface to an optics. The groups had been monitored over a period of 15 days. The product of each group was evaluated by the lecturer.

C. Design of Experiment

In the design of the experiment, we formed four groups of three participants each, by random allocation. Each group chose the channel of communication that they would use during the meetings. In the following, the groups are labeled as G1 (‘Second Life with the SLMeetingRoom’), G2 (‘Second Life without the SLMeetingRoom’), G3 (videoconference) and G4 (face-to-face).

The group in face-to-face condition worked in a meeting room available at the ADDLabs (Active Documentation Design Laboratory), in UFF (Federal Fluminense University). The room contained a table, chairs, paper, pens and available network for using personal laptops. The meetings were video-recorded. Figure 2 shows a meeting of the face-to-face group.

Figure 2. Face-to-face group during work meeting.

The group in videoconference condition used a software called ooVoo (http://www. oovoo.com), which is also used by [23] in their experiments. The conversations and chat logs were recorded. Figure 3 shows the videoconference group during the meeting.

Figure 3. Videoconference group during work meeting.

For the group in 'Second Life without the SLMeetingRoom' condition a meeting room was built in ADDLabs Island at Second Life. The group acted without any component to support the process of holding meetings, only with a table, chair, typing in chat rooms and audio. The conversations and the chat logs were recorded. Figure 4 shows the group

participants in the meeting room, highlighting one participant acting voice.

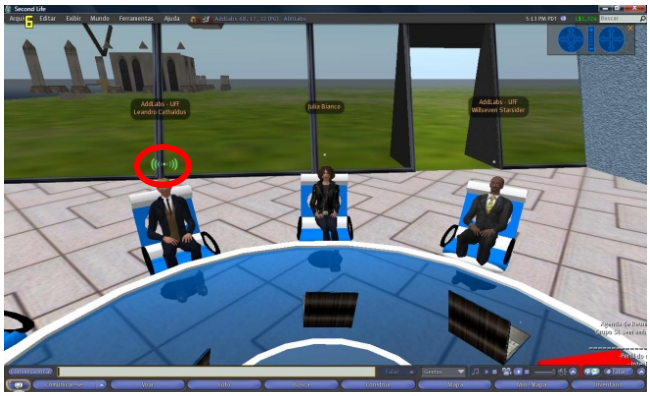

Figure 4. 'Second Life without the SLMeetingRoom' group during work meeting.

A meeting room with the previously described additional components was set up to host G1 (SL with SLMeetingRoom) work meetings. Figure 5 shows the group in action.

Figure 5. 'SL with SLMeetingRoom' group during work meeting.

D. Procedure

In each one of the groups, four one-hour meetings were held, performing a total of 16 meetings. A rule imposed to all groups established that the work should be done in a single platform.

Before the meeting, participants filled the 'Participant Profile Questionnaire' based on [24]. The participants also completed and signed the 'Statement of Consent' adapted from http://www.proac.uff.br/cep and the 'Statement of Authorization for Use of Picture and Testimonials' adapted from http://www.unigranrio.br/comite_etica. After each meeting, the participants filled the 'Post-meeting Questionnaire' based on 5-point Likert scale, where they were questioned about their impressions while using the chosen setup for holding meetings.

All meetings were attended by an observer who was given the attribution to film, record the time, take some notes, but he was also instructed to not communicate with the participants.

E. Measures

We have adopted a quantitative analysis approach for understanding and evaluating the development of the meetings, according to different conditions. In the following, we present our criteria for evaluation.

1) Tasks Completeness

Recent studies [25] have shown that the use of meeting schedules improves the quality of the results, increasing the satisfaction and reducing the wasted time.

This evaluation criterion measures how much of the tasks could be performed within the prescribed time of one hour. The reason for setting a limit for time was avoid engagement in repetitive and excessively detailed discussions. Thus, the intention was to restrict the meeting time to coordinate work, share information, forming sound decisions in order to establish group consensus, generating a high quality final product.

This criterion was measured by the number of tasks on the agenda, the number of tasks executed on the agenda during the meeting, the time spent to conduct the meeting and subjective questions on the questionnaire on post-meeting based on [26].

2) Participation Level

The evaluation of participation level was based on the time during which a single participant speaks (turn), the number of turns and a rate between these two quantities. Evaluating participation in meetings was studied in [27],[28] and [29].

The turn is taken from the moment that a participant begins to speak, until the moment he finishes his speech [30]. Like the approach used by [32], we define the turn as the time during which a participant speaks, regardless the unsuccessful interruptions or overlapping speech of another participant. A turn ends by an interruption caused by another participant that resulted in stop talking or a significant period of silence/pause. The conversations were transcribed manually in details, including pauses, silence and others ruptures. We used the transcripts to identify words of dialogue. The time spent was measured in seconds.

For groups that used the audio as communication channel, the duration of the turn was measured by timed speech of each participant. On the other hand, for the group that used the chat as communication channel, the duration of conversation turn was measured by the participant time spent on typing when formulating his speech.

The participation level of the group was measured by the average number of turns, computed from all participants, the average duration of a turn and also subjective questions in the post-meeting questionnaire based on [26][28].

F. Cognitive Effort

Cognitive effort (ease or difficulty) was measured through subjective questions in the 'post-meeting' questionnaire. For this criteria we used questions based on the NASA-TLX [33], a free tool for subjective evaluation of workload of a particular user. The NASA-TLX tool is based on six subscales that represent somewhat independent clusters of variables: mental

demands, physical demands, temporal demands, frustration, effort and performance [33].

G. Sense of Presence

Although presence is most studied in research on virtual environments (VE), the concept is also applicable to the study of computer mediated communication (CMC) and 3D virtual environments. The sense of presence is a subjective experience [29]. Thus, a commonly used definition for it is being in one place, even when you are physically located in another [34]. In this work, we based our analysis in this definition.

According to [35], there is no ideal instrument to assess the presence, although such instruments have already been described for more than a decade [36]. In this work we used subjective (post-immersion questionnaires) and objective measures (linguistic analysis).

Linguistic analysis used was based on [22] who proposed a method for measuring the sense of presence based on linguistic features of the dialogue, i.e., if a participant speaks of a remote space in the same way as he talks about the local space, we can infer that he feels present in this remote space. Kramer [22] used the analysis of conversations to identify the local and remote deixis, pronouns and other categories of words that represent or do not represent a sense of presence. After that, we correlated the self-reported feeling of presence with the use of specific linguistic features.

The linguistic analysis proposed by Kramer [22] was adapted for this research, considering the individual characteristics of its participants and the context in which it was applied. The adaptation allowed us to analyze the sense of presence in the group and the sense of presence in the environment, through pronouns and deixis, used by participants during the conversation shifts. This was used to analyze the following linguistic categories: Sense of presence in group (I, we, you); Sense of presence in the environment (deixis local and remote).

V. RESULTS

The statistical test of hypotheses framework was used to find differences between groups. With the nonparametric JT (Jonckheere-Terpstra) test for ordered alternatives, it was possible to write an alternative hypothesis that expressed our expected order of groups in the different criteria.

We applied the Jonckheere-Terpstra test to three variables: participation level, cognitive effort and sense of presence. We consider the significance level of 0.05 (5%).

The face-to-face group was used as a reference group for comparison. The face-to-face interactions are regarded as the "gold standard" for collaborative work [12] and they are often used as a model for interaction design [37], as well as judging new technologies [39].

A. Tasks Completeness

As long as the results of tasks completeness showed not much variation, we did not test hypotheses about this variable. Only the 'SL with SLMeetingRoom' group exceeded the stipulated time of one hour for a meeting, bringing negative consequences in the realization of the tasks of the meeting agenda.

B. Participation Level

1) Comparison between Groups

To illustrate the differences in the participation of each group, we presented Figure 6, the box-plot concerning the participation level in all groups at all meetings.

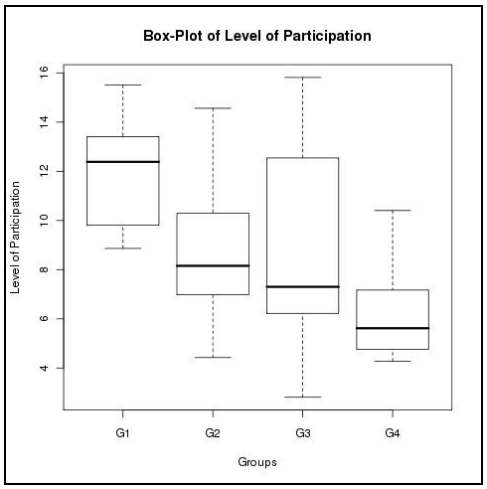

Figure 6. Box-plot of participation level among groups

2) Correlation with survey

We test the significance of correlation between the average per turn and the questionnaire answers, we obtained a correlation of 0.141 and a p-value = 0.859, i.e., the correlation was not statistically significant (p-value>0.05). However, we tested the correlation between the real-time participation and the questionnaire answers, we obtained a highly significant correlation of 0.989 and a p-value = 0.011.

3) Testing Hypotheses with the participation data

For the application of the Jonckheere-Terpstra test, the hypotheses were:

$$H_0: G1 = G2 = G3 = G4$$

$$H_1: G2 \leq G3 \leq G1 \leq G4$$

After applying the Jonckheere-Terpstra test we obtained a p-value = 0.8703. The significance of the result obtained by p-value is above 5% (p> 0.05), making it likely that the groups are equal, or the order of groups is different from the order defined for the alternative hypothesis, i.e. there isn't evidence in favor of H_1.

C. Cognitive Effort

1) Comparison between Groups

To illustrate the differences of cognitive effort in each group at every meeting, we present the box-plot in Figure 7.

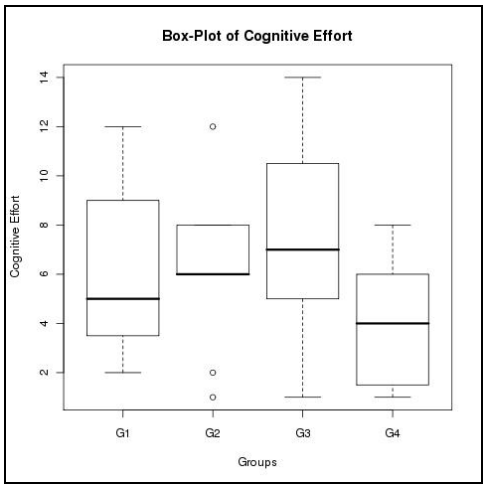

Figure 7. Box-plot of Cognitive Effort among groups

2) Testing Hypotheses with the Cognitive Effort data

For the application of the Jonckheere-Terpstra test, the hypotheses were:

$$H_0: G1 = G2 = G3 = G4$$

$$H_1: G2 \geq G3 \geq G1 \geq G4$$

The p-value found was 0.0065, i.e., there is evidence that the cognitive effort of the group using the proposed model is closer to the face-to-face than to the other groups.

D. Sense of Presence

1) Factor analysis

We adapted the procedure in [22] and carried a Factor Analysis to obtain three latent unobserved variables to represent Sense of Presence. The post-meeting questionnaire, based on [22], was submitted to a Factor Analysis with Varimax Rotation. As shown in Table I, the solution revealed three factors explaining 76% of data variance.

We tried to give some interpretation to the factors outputted from Factor Analysis. Factor 1 was called Objects, which indicated how the participants made references to objects in the workspace; Factor 2 was named Environment, indicating how the participants referred to the workspace, and Factor 3 was called Group, reporting how the participant feels in relation to working partners.

Factor 1 explained 31% of data variation, Factor 2 explained 25% and Factor 3 explained 20%. In this Varimax Factor Analysis it was tested a hypothesis that verified if the three factors were sufficient to understand the variation of the data. The p-value was 0.0186, thus the model is significant ($p<0.05$). The gaps in Table I occurred when the question was not sufficiently important to the factor. We created presence scores based on factor loadings.

TABLE I. QUESTIONS AND LOAD FACTORS ENCOUNTERED IN FACTOR ANALYSIS WITH VARIMAX ROTATION

	Factor 1 Objects	**Factor 2 Environment**	**Factor 3 Group**
Question 1	--	0.488	0.320
Question 2	0.471	0.748	---
Question 3	---	0.220	0.971
Question 4	0.475	0.770	0.271
Question 5	0.581	---	0.513
Question 6	0.918	0.334	---
Question 7	0.749	0.404	0.128

2) Predictive factors for the Sense of Presence

As proposed by [22], to verify the feasibility of using linguistic variables as predictors of presence, we conducted a regression to predict the presence scores of the participants from linguistic measures.

The regression for Factor 1 explained 16% of the variation in presence scores ($R^2 = 0.168$; $F[7,40] = 1.151$; p-valor = 0.352). Regression for Factor 2 was significant, explaining 27% of the variability in presence scores ($R^2 = 0.275$; $F[7,40] = 2.169$; p-valor = 0.0580). And finally, Factor 3 explained 9% of the presence scores ($R^2 = 0.098$; $F[7,40] = 0.618$; p-value = 0.738).

3) Testing Hypotheses with the presence data

For the application of the Jonckheere-Terpstra test, the hypotheses were:

$$H_0: G1 = G2 = G3 = G4$$

$$H_1: G2 \leq G3 \leq G1 \leq G4$$

The p-values obtained for Factor 1, 2 and 3 were respectively 1.681e-06, 0.012 and 0.025. In all these factors, we found evidence in favor of the alternative hypothesis (H_1), i.e., the sense of presence of the group using the proposed model was closer to face-to-face group than the other groups.

VI. DISCUSSION

Our research hypothesis is that if we enrich the Second Life, with the creation of an environment model that provides a set of essential components to support work meetings, we could make meetings results to be closer to the face-to-face ones.

As mentioned earlier, for tasks completeness criterion, there were not much variation in the results since all groups had completed their tasks, except SL with SLMeetingRoom in one of the meetings. We believe that this has occurred because the communication was via text what makes the speed of conversation to be slower than usual. Due to low variability, we did not test hypotheses.

In the analysis of level of participation criterion, we can verify in Figure 6 that face-to-face group (G4) had the lowest average in participation. This fact, however, was expected since the audio/visual media is more dynamic and rapidly transmitted in many turns [38].

The average participation of 'SL with the SLMeetingRoom' group (G1) was the farthest from the face-to-face group. We believe that the high average of this group occurred because the communication was via text, i.e., the conversation turns are higher due to the time that had been spent on reading, typing and formulating content. Hypothesis testing with the

participation data showed a p-value = 0.870, not evidencing the ordination established in H_1.

The correlation test between the average time of speech per turn and the scores obtained from questionnaire answers resulted in a p-value = 0.859, i.e., the correlation was not significant. However, when we tested the correlation between the real-time participation of groups and the scores in questionnaire answers, we obtained a highly significant correlation with p-value = 0.011. Thus, we conclude that the participants associate the degree of participation with the amount of time talking and not with the average time of participation.

For the cognitive effort criterion we can verify in Figure 7 that the face-to-face group (G4) was the group with less cognitive effort to carry the meetings out. This is due to the fact that face-to-face interactions are easy and natural [31]. The groups using Second Life presented averages very close to one another.

Contrary to expectations, the group that used video conference was the most distant from face-to-face group, in the criterion of cognitive effort. This fact may be related to some difficulties presented during the meetings in this media, mainly problems of bandwidth. In relation to our research hypothesis, we found evidence that the group using the model SLMeetingRoom is the closest to the face-to-face group.

For the criterion of sense of presence the hypothesis testing presented a high significance in all factors ($p < 0.05$). In relation to our research hypothesis, we found evidence that the videoconference group and the 'SL without the SLMeetingRoom' group are the most distant groups from the face-to-face in all factors, confirming the initial research hypothesis, that the group using the SLMeetingRoom model will present a greater sense of presence, more than just using the traditional Second Life and videoconference systems.

When trying to adjust a regression model of the factor scores as a function of linguistic variables, only Factor 2 (Environment) was significant.

Only the regression model for Factor 2 was significant ($p = 0.05$), explaining 27% of the total variability in the presence scores. Kramer [22], in his analysis, had a sample of N = 148 and got 33% of variability explanation. Taking into consideration the size of our sample (N=48), we believe that the significance of 27% is quite promising. It is necessary to have trials with a larger sample to check the increasing of significance.

In this study, the expected results occurred for the criteria of cognitive effort and sense of presence. However, for the tasks completeness and participation level, we did not find evidence to support our research hypotheses.

These results encouraged us to seek better understanding about what are the gains in using a prepared environment to support meetings in Second Life. Future work will be made with experiments to compare the two conditions, 'SL with the SLMeetingRoom' and 'SL without the SLMeetingRoom', using more people, more meetings and another task.

VII. Conclusion

This paper addressed the problem of using Second Life as a platform for meetings. Aiming to solve our research problem, we proposed the creation of a model environment to support the basic activities of meetings. This model was called SLMeetingRoom, a meeting room in Second Life composed of ten essential components to support activities such as communication, coordination, cooperation and awareness.

Our stated hypothesis was that by the use of SLMeetingRoom we could enable meeting results to closer to face-to-face. Thus, we tried to get evidence through a pilot study with graduate students of Federal Fluminense University.

In the pilot study we observed a sequence of meetings that were videotaped, audio-recorded and had their chat logs recorded. Through statistical analysis of data, we concluded that SLMeetingRoom was a promising alternative according to cognitive effort and sense of presence criteria.

Our study showed evidences that the Second Life environment could coexist with videoconferencing, EMS, audio conferencing and screen sharing as a tool for the realization of synchronous remote meetings. Finally, we are encouraged to perform larger experiments with more participants in the groups, with different profiles (level of academic education, occupation, etc.).

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