BUILDING AN APPROACH TO WORK TOGETHER IN SECOND LIFE

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ABSTRACT
Computer Supported Cooperative Work or, CSCW, is an area that aims to understand how technology works in the performance of work and tasks together, covering the computational support of activities involving more than one person [1]. Studies and experiments in Second Life helped confirm the need for an approach that facilitates collaborative work. This article describes the activities carried out by a group of students to develop a minimum set of tools to improve collaboration in meetings of acquiring knowledge and decision making. Will be presented in this article the activities carried out, the challenges encountered, challenges and results. The project of creation of this new approach of collaborative work, covered the activities of software development life cycle such as requirements analysis, specification (use cases, GOMS, storyboards), implementation, execution, testing and evaluation.

Categories and Subject Descriptors
H.5 [**Information Interfaces and Presentation (e.g., HCI)**]: H5.3 Group and Organization Interfaces – collaborative computing, computer-supported cooperative work, synchronous interaction.

General Terms
Design, Experimentation and Human Factors.

Keywords
CSCW, collaborative work, collaborative approach, software development life cycle

1. INTRODUCTION
A Collaborative Virtual Environment (CVE) is an interaction space that supports the construction, integration and exchange of information of participants in order to interact for task completion, achieving goals, knowledge building, social networking, and other interactions.

The abundant amount of data and the granularity of the interactions of collaborative environments have stimulated numerous investigations into forms of cooperation and collaboration in these environments. Sparking the interest of the community CSCW (Computer Supported Cooperative Work), due to the richness and variety of interaction and immersion, is the name of the area of research that studies the use of computer and communication technologies to support activities of groups and organizations [2].

Within this universe we highlight the Second Life (www.secondlife.com), a 3D virtual environment, the world's most popular, where players develop strong social bonds interacting with objects, forming groups and participating in activities of significant value [3][4][5]. The affordances of 3D environments facilitate communication, emotional and also social interaction among participants [6].

Second Life is an environment rich with opportunities for interaction that gives the participant a sense of presence very strong, but still has major limitations in the process of interaction with others and the world. After numerous studies and experiments with the environment, the team noted the need to develop an approach that facilitate collaborative work, in other words, a minimum set of tools to improve collaboration in meetings of acquiring knowledge and decision making.

This paper describes the experience of developing a collaborative project within Second Life. The project of creation of this approach for collaborative work covered the activities of software development life cycle such as requirements analysis, specification (use cases, GOMS, Storyboards), implementation, execution, testing and evaluation. All activities were held inside Second Life. It was not necessary to use external tools.

2. RELATED WORK
Numerous studies in the field of HCI (Human-Computer Interaction) have reported the use of 3D virtual environments like Second Life, to conduct collaborative work and the behaviors that involve this process. “Traditional” criteria of analysis for CSCW tools have been applied to Second Life and it can be concluded that Second Life is a good tool for collaborative work, especially in remote support of synchronous collaboration (at the same time), providing an experience almost co-located (face-to-face) [5].

Groups can work together effectively in Second Life, but it is necessary to coordinate the process of collaboration. For this the authors developed a proposal to support the management of collaborative activities called SLMeeting [7]. SLMeeting

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facilitates communication in Second Life, organizing conferences and workshops, reproducing, querying, analyzing and visualizing the information generated.

Even the look can influence a collaborative activity. The act of "looking" within a virtual collaborative environment is a long action. [8] The blink of an eye, in turn, may influence not only the collaborative activity, but also the impressions conveyed to viewers [9]. Real world experiences are often replicated in virtual worlds due to the high level of immersion that these environments provide. Studies about the mobility patterns of users of Second Life showed that users are generally concentrated around points of interest and they walk short distances in most cases [10].

There is a great need to capture and share memories and experiences in the virtual world. [11] This sharing is due to the necessity of transmitting knowledge because the perception in a collaborative environment is an important factor. People like to know about the situation of group members and changes in the system [12].

A few years ago the Software Engineering had numerous failures in dealing with aspects of the group that is very needed in collaborative applications [13], but now it has grown significantly in the development of collaborative applications. [14] Challenges for distributed work teams using virtual worlds have been studied [15][16][17]. Although new professional face difficulties in entering into activities in virtual environments [6], it is possible to formulate approaches of engineering software for project and implementation of collaborative systems [18].

3. DEVELOPMENT CYCLE OF COMPONENTS

The students created a work room in Second Life for the team to share information, online or offline, about development, documentation, implementation, descriptions and evaluation. The work room became a meeting place for the team, with extensive use of voice communication (synchronous) and text (synchronous and asynchronous), and the use of gestures to enhance communication, and consequently the immersion of the members team.

3.1 Requirements Analysis

Past experiences and analysis of the problem domain confirmed by the necessity of building components to improve collaboration in meetings and for acquiring knowledge and decision making. We note that Second Life does not provide a set of components that facilitate collaborative meetings with small groups. Some proposals were found in the literature, but required a good knowledge of the environment, use of external services and the need for a coordinator to lead the meeting and support the work of the participants.

The proposal is to create an easy approach and friendly to support small groups in meetings of acquiring knowledge and decision making. At this stage, research was done to understand how meetings are conducted in the real world and the real needs of participants.

Five components to support the collaborative process of the meeting are necessary. These components are: meeting agenda, timeline of activity, model of argumentation, wiki, social proxy and degree of interest of the participants. The requirements analysis allowed describe "what" each component should do. All components were developed within Second Life using their resources modeling (3D visual objects) and programming (scripting language LSL).

3.2 Specifications of the Environment

At this stage the team endeavored to describe/design the interface and the utilization of interaction objects. All specifications were made available in the work room in Second Life for the implementers consult with other team members.

3.2.1 Use cases

The diagrams and descriptions of the use cases were generated from the requirements analysis. The system of three-dimensional modeling of Second Life allowed the use of primitives for a better view of the diagram use case, as in Figure 1.

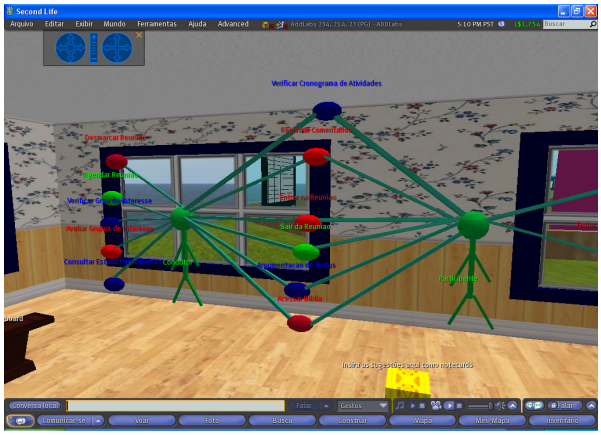

Figure 1. Use Case Diagram modeled in Second Life.

3.2.2 GOMS

GOMS (Goals, Operators, Methods, and Selection Rules) is a method that represents the cognitive structure of the user in terms of goals, operators, methods and selection rules [19]. It is used as a tool to view interactions from the perspective of the User [20].

3.2.3 Storyboards

The storyboard is a drawing of how interaction is organized. [20] It is a draft of the interaction, where it can define the resources and time for implementation. It can be used in various application areas, in analysis, design or evaluation. In the analysis phase, the storyboard is the visualization of the scenario; in the design phase, it is what we can visualize the use of interface; and in the evaluation phase, the usability tests are made in it and the environment is redesign if necessary.

3.3 Implementation

A view of collaborative systems are complex to develop [25] and, the transformation of the project specified for code language has become extremely important. In this moment the team must be careful so that the implementation produce results as close as possible to what was defined at the design stage, thus, the

implementation of the components was conducted through a strict and concise documentation.

The objects' behavior within Second Life has been defined by programming scripts. These scripts are developed with LSL (Linden Script Language), an interpreted language and event-driven [21]. It has a syntax similar to other object-oriented languages such as Java and C#, and provides the common features of these lineage, such as flow control structures, repetition, events and functions.

3.4 Execution

The execution was performed by testing of the team. After that, the components were made available to the group for realize the meetings experimental. The components are described in this section.

Agenda: This component aims to store personal commitments or group. It is one of the most used services during the cooperative work. The participant selects the desired date and receive a notecard (sort of text file used in Second Life), and inserts the commitment for the selected day, which can be viewed later. The agenda is specifies the current month and when there is an event marked the day is marked with a different color, as shown in Figure 2.

Figure 2. Agenda.

Timeline of activities: Component used to organize future tasks, their respective executors and their respective dates from the beginning to the end, controlling the progress of tasks and the perception of action of the members. The component displays the time remaining for completion of the task and if the task is delayed. Schedule is defined as a tool with fixed roles (creator, administrator, executor) and is easily perceived through the interface [28]. For Fuks [18], manage the progress of tasks is the most important stage of coordination, it is the most dynamic part of it, needing to be renegotiated in an almost continuous throughout the time. Figure 3 shows the Timeline of activities.

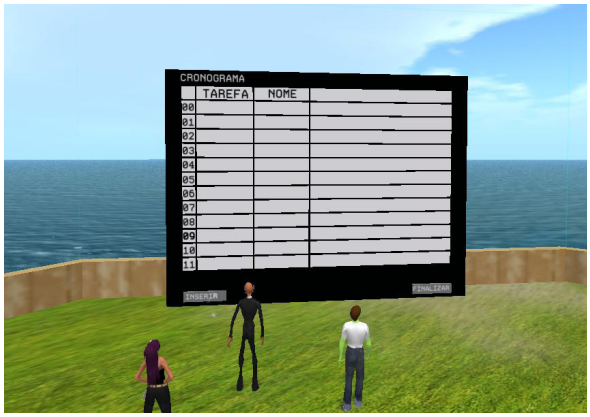

Figure 3. Timeline of activities.

Model of argumentation: Studies on models of argument have emerged since 1970, in order to categorize the messages [34]. The best known is the IBIS (Issue Based informatiom Systems), which provides techniques for structuring the discussions, being used as a decision support system, directing the content of the discussion [22]. Based on the model of argumentation and categorization of message IBIS, the argumentation model implemented for Second Life to structure a discussion through a system of questions, answers and arguments in a tree structure. Figure 4 shows the model of argument deployed to Second Life, where they were used geometric shapes and colors for better viewing of the discussion. The Issue/Question (white circle), Position/Response (green square) and Arguments (triangles). The argument was divided into two parts, arguments positive (blue triangle) and negative (red triangle).

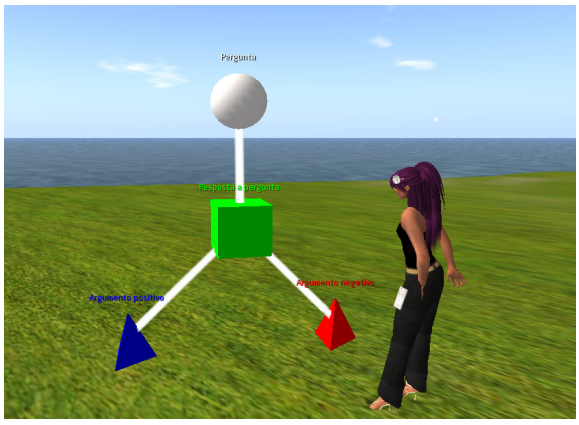

Figure 4. Model of argumentation.

Wiki: Simulates a system of wiki within Second Life, allowing the User to enter information in order to generate documentation. The wiki has control of users, content editing, historical control, versioning and concurrency control. Figure 5 shows the implementation of wiki.

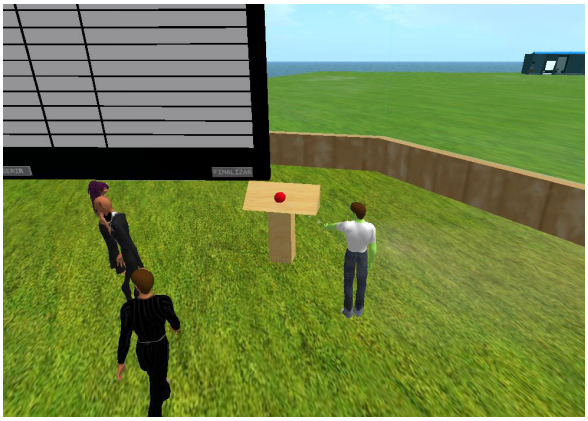

Figure 5. Wiki.

Social Proxy: Based on the problems of display and use of artifacts sets studied the social proxy, a minimalist view of the presence and activities of participants in an online interaction [23]. A very relevant Social Proxy is the perception (awareness), that is, knowledge about activities and about the group. Thus, the Social Proxy allows the participant to visualize the interaction of other users, whether or not they are participating in the discussion. Based on the six guidelines for developing the Social Proxy listed by Erickson [23] developed a version for Second Life in order to support collaborative meetings allowing each member has a view of the behavior of their group both on a global or local. There are three behaviors that can trigger changes in the Social Proxy: user on-line, off-line and typing. Figure 6 shows the social proxy during one of the meetings.

Figure 6. Social Proxy.

Degree of interest: through radar around the environment it, was possible to check the users' interest in certain objects by analyzing the time spent in each place [10]. The component was executed without the knowledge of participants in order to track the real interests of the same.

3.5 Experimentation

A groupware is usually a difficult system to implement and test, and is more vulnerable to failures [26]. The experimentation becomes necessary to adapt the collaborative system to each specific need [25].

In order to obtain responses from the user on the viability and quality of the components they had to be developed in experimental meetings. The experiment took place in ten meetings with seven volunteers, of about two hours each, where the invited participants had the opportunity to interact with the components.

The subjects were asked to complete the Questionnaire for the User Profile, which reveal the technological level of the participant and the Assessment Questionnaire, where the participant evaluates the productivity of reunion with the use of components and the components themselves.

The questionnaires were linked to modeled objects in Second Life, so that the participant did not have to go out of Second Life to answer the questions. With the tools to analyze the results it was possible to evaluate the productivity of the meeting with the use of specified components, as well as the level of acceptance of the components.

3.6 Evaluation

The usability tests can be divided into two groups, indirect methods (no users) or direct methods (with users). In this study the indirect method was used, known as Heuristic Evaluation.

A heuristic evaluation is a technique where an external evaluator is determined on an interaction to try to predict future problems. It can be used at any phase of the project through the evaluator who is to interpret the will of the User [24].

The evaluation of the components was made through the application of heuristic evaluation questionnaire at the interface and in the specifications (use cases, GOMS and Storyboard). After applying the heuristic evaluation questionnaire in the components, it was necessary to change the specification in order to remedy problems encountered.

4. ANALYSIS AND DISCUSSION

In order to obtain the level of acceptance of the user on the quality of the application developed, we held ten experimental meetings, within about two hours each, whence the participants (volunteers) had the opportunity to interact and observe the approach developed. After the completion of the experiment one can analyze and discuss the behavior and limitations of the participants during the meetings.

The synchronous communication was extremely exploited through instant messaging (IM) and chatting directly. Gestures were also used to strengthen the talks, and audio chats. The features of asynchronous communication in Second Life are not yet well developed [5]. The participants used the IM, which are sent by e-mail to a member off-line and notecards, which allow one to write messages.

The reading of past conversations presented problems because the chat is only available during the current session. It is very common that one participant is late for a meeting, and then they cannot recover the content that was discussed before they entered.

As for implementation, some problems were encountered in the creation of shared objects because Second Life does not allow shared editing scripts, thus the implementation of the scripts was made by a single-user. The programming language is still very limited as it does not have arrays, switch case, matrix, among others.

The sharing of knowledge occurred naturally and very often. It was common see the participants helping colleagues when there was a problem.

The biggest issues of infrastructure were with the bandwidth connection that hinders development. The Second Life does not have an offline mode. All the development is done through communication with the server, which means compiling and updating the code to the server for each new change, and the need to use the Internet to interact with objects. This creates problems that mask errors and leave the components difficult to test.

The lack of interoperability with other platforms was another problem. There was no possibility to share information outside of Second Life such as, for example, a text document or a spreadsheet.

The component called the degree of interest was developed to trace the participants, aiming to establish a monitor of their activities and points of interest. The analysis of results extracted with this component can be used for the environments developer has the possibility to understand their audience and thereby improve identifying the strengths and weaknesses, so that it can lead better future experiments. To cover the experimental meetings, seven sensors, were installed. The sensors are components created inside of Second Life (objects 3D and LSL language), that register the time that a participant stay in the place. Data extracted from the radar showed that the Wiki had a utilization of 13.7% of the time of the meeting, the agenda 4.3%, the timeline 4,6%, the model of argumentation 20.6%, table meeting 32.7% and 24.5% of the space entry. These data allow us to make some conclusions about the use of components. The figure 7 show the division of the data extracted from the radars.

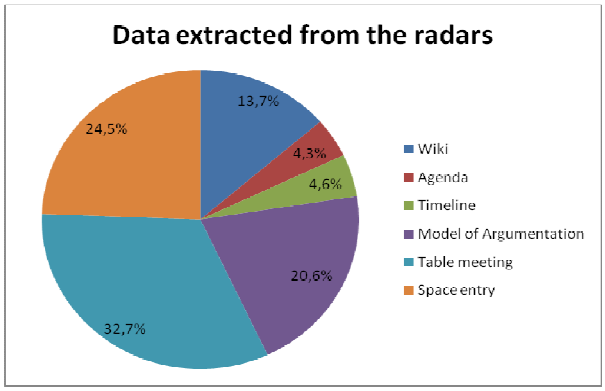

Figure 7. Data extracted from the radars.

The table meeting had the highest percentage of use (32.7%), considering that much of the time was reserved for group discussion. Already the space entry had an utilization of 24.5%, i.e., was the site where the group was in before the meeting, or waiting for some avatar to arrive.

The agenda and timeline ensured the coordination and communication. Coordination is an activity of importance as it organizes the group, and without it, the team can often be involved in conflicting or repetitive actions [1]. The effectiveness of communication and cooperation can be enhanced if the activities are coordinated, but the coordination requires an additional effort that will ensure compliance with the commitments made during the communication.

The agenda presented with an excellent component to support the group for the marking of future meetings, gatherings, etc. And the timeline was a tool to facilitate coordination of the work of the group. The two components are extremely simple and quick use, participants simply go to them and record information, which justifies its low percentage of use. An important point in using the agenda and the schedule is distributed asynchronous interaction, because its use is not restricted only to the meeting time, but their action is constant, by presenting visual information to participants.

The model of argument and the Wiki secured the cooperation, in order that the register of the interactions of group members was stored, cataloged, categorized and structured in these cooperation objects [18]. These were the methods used to ensure the memory of the collaborative group project. The model of argument and the Wiki, although important to structure the discussion, its use requires a slower pace, which justifies its high percentage of interest. Reports from participants showed that the model of argumentation is a great way to summarize all that was discussed.

The Social Proxy ensured the perception, and It was the most used component, that due to the fact that the participant used him throughout the meeting, from the moment of arrival the room until the end of it. According to Gerosa [25], see the activities of other individuals is essential to ensure the flow and naturalness of work, and thus decrease the feelings of impersonality and distance, common in virtual environments.

Participants reported that during the meeting, the Social Proxy was an informative and useful component because it is easy to know who is participating in meeting or not. The participants also reported to be a component that coordinates the participation process, reducing interruptions during conversations. The Social Proxy had some limitations, for example, cannot be scaled to large numbers of people, for his minimalist view does not allow viewing of large groups. The developed version supports a maximum of 12 participants.

Considering the learning problems, the experiments have shown that all participants could understand the fact that “some event was happening” when a cluster of balls near the center circle was displayed. Participants were solicitous in teaching the others members about the interpretation of signs. Knowledge sharing occurred naturally and very often. Participants usually helped each other when some problem occurred.

The development within Second Life is not a simple task, because the scripting language has many limitations and restrictions that hinder the development. In these cases, we had to find ways to overcome limitations and achieve the desired results.

Communication between components is a clear example, because communication between objects is done by sending messages. To implement the synchronism manually is a very cumbersome task, which could be simplified considerably if the language were more expressive and robust.

The edition of shared scripts is not supported by Second Life, thus the implementation of the scripts was done in single-user mode. The language is still very limited; it has no arrays, switch case,

matrices, and other structures common to conventional programming languages.

Infrastructure issues, especially the bandwidth, are also factors that hinder development. As it does not provide an "off-line" mode, all the development in Second Life must be done through client/server communications, that is to say compiling and updating the code on the server whenever a new change must be done. Also the need to use the Internet as means of interaction with objects, creates problems that hides errors and make components difficult to test.

In general all components guaranteed perception, some more, some less, considering that the components available in the environment gave the participants, support enough for them to press ahead with work, reducing the chances of a participant to interrupt his colleagues request information already available in the environment. Participants use the elements of perception to collect information about the status of activities and so perform actions based on the goals of collaboration [18].

Compared with studies in the literature, SLMeeting among others, our approach is extremely simple, fully developed and used within Second Life, it was not need any configuration or access the external server. The components provide information synchronous and asynchronous, allowing the coordination and facilitating the collaboration of the group during meetings.

5. CONCLUSION

This paper describes an approach to enhance collaboration and decision making in the groupware 3D platform known as Second Life. In virtual environments, social bonds become so strong that groups of people can work together to become as effective as a group meeting in real life. [27] But with the limitations, vulnerabilities, difficulties in implementation and testing [26], it was necessary to test each component developed in order to generate adaptations for specific needs and goals.

The meetings experimental included the presence of invited volunteers from the evaluation questionnaire, who gave a very positive opinion about the productivity of meetings and the use of components available.

As part of a larger project, our approach has been tested at the level of acceptance, which allowed us to verify the implementation and architecture used. For future work, we plan to conduct controlled experiments with user groups in collaborative activities in order to achieve more tangible results.

It can be said that although the many limitations and extra effort to avoid them, the end result is satisfactory. With the improvement of 3D virtual environments and their components, it is expected that the interaction will become increasingly simple and pleasant and attract a growing number of users.

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7. REFERENCES

[1] Ellis, C.A., Gibbs, S.J. & Rein, G.L. (1991) Groupware - Some Issues and Experiences. Communications of the ACM, Vol. 34, N. 1, pp. 38-58.

[2] Olson, G. M. and Olson, J. S. (1997). Research on computer supported cooperative work. Handbook of human-computer interaction, 2nd. Ed., Helander, M.G., Landawer, T.K., Prabhu, P.V. (ed.).

[3] Brown, B. and Bell, M. 2004. CSCW at play: 'there' as a collaborative virtual environment. In Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work CSCW '04. Chicago, Illinois, USA, November, 2004.

[4] Ducheneaut, N., Wen, M., Yee, N., and Wadley, G. 2009. Body and mind: a study of avatar personalization in three virtual worlds. In Proceedings of the 27th international Conference on Human Factors in Computing Systems CHI '09. Boston, MA, USA, April 04 - 09, 2009.

[5] Olivier, H., & Pinkwart, N. (2007). Computer Supported Cooperative Work In The Second Life? Position paper presented at the Track on Business in Second Life at the 3rd International Second Life Community Convention. Chicago.

[6] Bessière, K., Ellis, J., Kellogg, W. Acquiring a Professional "Second Life:" Problems and Prospects for theUse of Virtual Worlds in Business. 27th Annual CHI Conference on Human Factors in Computing Systems. April 4-9. Boston, MA, 2009.

[7] De Lucia, A., Francese, R., Passero, I., Tortora, G. SLMeeting: Supporting Collaborative Work in Second Life. Proceedings of the working conference on Advanced visual interfaces. Pages 301-304. Napoli, Italy, 2008.

[8] Neustaedter, C. and Fedorovskaya, E. 2009. Capturing and sharing memories in a virtual world. Proceedings of the 27th international Conference on Human Factors in Computing Systems. CHI '09. Boston, MA, USA, April 04 - 09, 2009.

[9] Irani, L. C., Hayes, G. R., and Dourish, P. 2008. Situated practices of looking: visual practice in an online world. In Proceedings of the ACM 2008 Conference on Computer Supported Cooperative Work (San Diego, CA, USA, November 08 - 12, 2008). CSCW '08.

[10] La, C. and Michiardi, P. 2008. Characterizing user mobility in Second Life. In *Proceedings of the First Workshop on online Social Networks* (Seattle, WA, USA, August 18 - 18, 2008). WOSP '08.

[11] DiPaola S. and Collins C. A 3D Virtual Environment for Social Telepresence. Western Computer Graphics Symposium, '02, - Paper - 2002.

[12] Bos, N., Shami, N. S., Olson, J. S., Cheshin, A., and Nan, N. 2004. In-group/out-group effects in distributed teams: an experimental simulation. In Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work CSCW '04. Chicago, Illinois, USA, November 06 - 10, 2004.

[13] Grudin, J. 1994. Groupware and Social Dynamics: Eight Challenges for Developers. Communications of the ACM 37, (1), 92-105.

[14] Demarco, T., and Lister, T., 1999. Peopleware: Productive Projects and Teams. Dorset House Publishing, USA.

[15] Bordia, P. Face-to-face vs. computer-mediated communication: A synthesis of the experimental literature. The Journal of Business Communication, 34(1), 1997.

[16] Hattie, J., Marsh, H. W., Neill, J. T., and Richards, G. E. “Adventure Education and Outward Bound: Out-of-Class Experiences that Make a Lasting Difference.” Review of Educational Research 67(1), 1997, 43-87.

[17] Nardi, B. Strangers and friends: Collaborative play in World of Warcraft. In Proceedings of Computer-Supported Cooperative Work, 2006. New York: ACM Press.

[18] Fuks, H., Raposo, A.B. & Gerosa, M.A. (2003) "Do Modelo de Colaboração 3C à Engenharia de Groupware", IX Simpósio Brasileiro de Sistemas Multimídia e Web – Webmidia 2003.

[19] Nielsen J. (1993). Usabilty Engineering, Morgan Kaufmann, Inc. San Francisco.

[20] Silva, C., Tavares, T., Thomaselli, J., Garcia, A. Governo Eletrônico em Ambientes Colaborativos Virtuais. SBSI - V Simpósio Brasileiro de Sistemas de Informação, Brasilia. 2009.

[21] Rymaszewski, W., Au, W., Wallace, M., Winters, C., Ondrejka, C., Batstone-Cunningham, B. Second Life® The Official Guide. Publisher Wiley, 2007.

[22] Conklin, J.; Begeman, M. L. (1998) gIBIS: A Hypertext Toll for Exploratory Policy Discussion. ACM Transactions on Office Informations Systems, Vol.6, No. 4, 303-331.

[23] Erickson, T. 2008. ‘Social’ systems: designing digital systems that support social intelligence. AI Soc. 23, 2 (Aug. 2008), 147-166.

[24] Nielsen, J. (1994). Heuristic evaluation. In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, NY.

[25] Gerosa, M.A., Pimentel, M., Filippo, D., Barreto, C.G., Raposo, A.B., Fuks, H. & Lucena, C.J.P. (2005) "Componentes Baseados no Modelo 3C para o Desenvolvimento de Ferramentas Colaborativas", Anais do 5º Workshop de Desenvolvimento Baseado em Componentes - WDBC 2005, 07-09 de Novembro, Juiz de Fora-MG, ISBN 85-88279-47-9, pp. 109-112.

[26] Grudin, J. (1989): Why Groupware Applications Fail: Problems In Design And Evaluation. Office: Technology And People, vol. 4, no. 3, pp. 245-264.

[27] Poletto, A., Schmitz, A. Gontijo, L. Revisão de Aspectos Teóricos e Metodológicos do Uso de Mapas Cognitivos na Ergonomia. Universidade Federal de Santa Catarina. Florianópolis – SC – Brasil. ISSN 1676 - 1901 / Vol. 8/ Num. 2/ Julho de 2008.

[28] Tornaghi, A. (1995). MULEC - "MULti-Editor Cooperativo para Aprendizagem", Master Dissertation, Supervisor: Jano Moreira de Souza, PESC-Coppe/UFRJ.