SUPPORTING AWARENESS IN EDUCATION: OVERVIEW AND MECHANISMS

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Abstract — *This paper discusses awareness support in educational context, focusing on the support offered by collaborative virtual environments. Awareness plays an important role in everyday educational activities, especially in engineering courses where projects and group work is an integral part of the curriculum. In this paper we will provide a general overview of awareness in computer supported cooperative work and then focus on the awareness mechanisms offered by CVEs. We will also discuss the role and importance of these mechanisms in educational context and make some comparisons between awareness support in CVEs and in more traditional tools.*

Index Terms ¾ Awareness mechanisms, Collaborative Virtual Environments, Learning communities, Social awareness.

INTRODUCTION

Learning is essentially a social activity [34, 35]. The social dimension of learning is of paramount importance in engineering project-based courses, where a high degree of cooperation is required. To be able to accomplish a task and maintain a comfortable social climate in the learning community or group, to be able to function effectively in both working and social activities, the students need to constantly maintain a high degree of *social awareness*.

There exist a number of different definitions of social awareness in the literature. In a first group of definitions, (see e.g. [32, 25, 13]), social awareness is defined as awareness about the social situation of other people, i.e. what they are doing, whether they are engaged in a conversation and can be disturbed, and of who is around and what is up. All these definitions consider mostly events that happen at a certain moment of time. Definitions in a second group are more general and assume a broader context. An example is group-structural (structural) awareness defined by [13] as knowledge about people's roles, positions, status, responsibilities and group processes. Similarly, according to [10] and [14] social awareness is awareness about the social connections within a group. Starting from the existing definitions we arrived at a new definition that takes care of both general concepts and concrete events:

Social awareness is awareness of the social situation in a group or community in a shared environment, which can be physical, virtual or both: people's roles, activities, positions, status, responsibilities, social connections and group processes. Social awareness encompasses awareness of social situation in general and social situation at a certain moment. The knowledge about the general social situation can be achieved by answering among others following questions:

- What is the structure of the group?
- What are the relations between group members?
- How to interact with the other group members?
- What are the roles of group members, and what resources are associated with these roles (for example knowledge)?

The awareness or knowledge of a general social situation is acquired by collecting and analyzing awareness information from social situations at a certain moment and answering questions like who is present, who is available and who is doing what and talking to whom at the moment.

Social awareness in real world is often achieved by collecting different cues from the environment [3], for example, by looking at what other people in the same room are doing, their conversational patterns and emotional state. In empirical study that we conducted, described in Section 2, shows that university does not provide an optimal environment for extracting such cues and supporting social awareness. In Section 3, we will also show that existing tools, such as ICQ and BCSW, are not effective enough for supporting social awareness in education. Therefore, in Section 4, we will look at an alternative way of supporting social awareness by using collaborative virtual environments (CVEs). A Collaborative Virtual Environment (CVE) is a computer-based, distributed, virtual space where people can meet and interact with others, with agents or with virtual objects [28]. CVEs have been widely used in educational settings of different types, ranging from K-12 to higher education. Mainly, they have been adopted for their potentiality of offering a new space for promoting socialization. In this paper we will discuss CVEs focusing on the awareness mechanisms that they make available and their importance in the educational context.

SOCIAL AWARENESS IN UNIVERSITIES

In order to find out the role of social awareness in education and the ways and limitations in collecting social cues, we performed an empirical study among computer science students. In this study we have distributed a questionnaire to the students residing in two major computer labs in our

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university. In the questionnaires the students were requested to indicate:

- To what extent they are aware over a number of components of social awareness in their own and other classes sharing the same computer lab, such as: possessed resources (knowledge, skills), group membership, social relations, activities and responsibility division in groups.
- To what extent different locations/virtual spaces in the university (computer lab, classroom, class party, canteen, newsgroups, library, "oasis") are suitable for supporting social awareness.
- What mechanisms they use to acquire social awareness (sitting next to friends, observing how other students behave and how they work, asking other students directly, using technical tools like ICQ and mobile).

A detailed description of the results of this questionnaire is beyond the scope of this paper. Here we simply want to outline some major trends.

- Students appear to be more aware about resources, and group membership, to a slightly less degree social relations, and to an even less degree on activities and responsibility division within groups in their own class.
- All groups show a dramatic drop in awareness when other classes using the same computer lab are concerned.
- In both computer labs students point out computer lab and class parties as the best places to get acquainted to new people and share knowledge, with the classroom and canteen on the second place. The places rated lowest are mailing lists/newsgroups, oasis and libraries.
- All the groups point out sitting together near their friends/partners as the major way of achieving social awareness, with technical tools on the second place.
- Use of technical tools is as follows: e-mail, mobile, ICQ in descending order.
- Students generally agree that an increased social awareness will result in a number of positive consequences, such as better learning, social environment and meeting and working place.
- All students generally agree that learning is more effective within a community.

From this we may conclude that the students experience problems with acquiring enough social awareness in their everyday life and work. Many students appear not sufficiently aware on the activities and responsibility division in groups, though these are the central components of effective learning as discussed in [8]. In addition, this lack of awareness can result in poor information sharing and effort duplication, when the students are not aware of the resources available in their own and other classes. When students try to acquire awareness, they mostly prefer to keep close to their friends/partners or use technical tools like ICQ, mobile and e-mail, and are more reluctant to observe other students or contact them directly. This indicates that the students often limit themselves to a narrow circle of immediate friends and working partners and feel more comfortable about using technical tools then contacting peers directly.

These results indicate that even students that share a common working place (computer lab) fail to achieve a satisfactory level of social awareness. It is natural to assume that awareness acquiring is even more complicated for those students who for various reasons are unable to attend the workplace regularly. We can conclude that the "natural" mechanisms are not sufficient for supporting social awareness, therefore we will look at how technical tools, both traditional CSCW ones and CVEs, can contribute to increase awareness.

AWARENESS MECHANISMS IN TRADITIONAL TOOLS

General mechanisms for supporting awareness

The field of CSCW (Computer Supported Cooperative Work) has since its beginning acknowledged the importance of awareness in cooperative work. Efforts have been devoted to the understanding of the social mechanisms that are used in everyday life to support cooperation as well as to the development of tools for increasing awareness when these mechanisms are not sufficient, e.g. when people are geographically distributed.

Gutwin, Greenberg and Roseman in [13] identify following general mechanisms for maintaining awareness among people that share a common workspace:

- Direct communication. People explicitly provide information about their interaction in the shared workspace. Most of the communication is verbal, though gestures are common as well
- Indirect productions. Communication through actions or expressions.
- Consequential communication. Listening or watching to others as they work.
- Feedthrough. Observing the effects of other people's actions on the artifacts in the shared workspace.
- Environmental feedback. Perceiving of a higher-level feedthrough from the indirect effects of other people's actions in the larger workspace.

When supporting social awareness people use one or more these mechanisms. For example, to achieve awareness of the social structures in a class, students can both communicate directly to other students, observe their activities and behavior and analyze the effects of their actions on the artifacts and space structure (areas occupied by different groups, notes on the messages boards etc).

The mechanisms for providing awareness, especially social awareness, can also be classified according to whether awareness information is provided actively by the user or collected passively by a system and then presented to its users [7, 32]. For example, some systems allow users to post information about themselves to make other users aware e.g. of their interests (active awareness). The system can also detect automatically whether a user is online or not, and make other users aware of it (passive awareness).

In the next section we will look at how CSCW tools support social awareness and discuss their limitations.

Supporting social awareness by CSCW tools

The results of our empirical studies showed that students use different technical tools for achieving social awareness, such as e-mail, ICQ, and mobile phones, and that the use of tools was put on the second place after sitting next to friends and partners. However, we argue that these "traditional" tools are not sufficient for supporting social awareness the way we defined it.

ICQ is an Internet tool for supporting communication (www.icq.com). It provides the awareness about whom from the user's contact list is available for conversation, who is temporarily unavailable and who is off-line. However, ICQ does not provide support for "weak ties", those contacts that are not in our primary list, but still important for our work [17]. ICQ users can exchange mails, text messages, and files; can chat with both persons from the contact list and random ICQ users. However, ICQ cannot convey the visual information about the users' mimics and gestures, appearance, position and orientation relative to other users, as well as provide support for "chance encounters", an important mechanism for supporting awareness. Huxor in [17] argues that such chance encounters are dependant on the spatial arrangement. Together with the possibility of meeting a person and initiating a conversation, the spatial arrangement of the meeting place provides a possibility for negotiating of communication, for example "looking busy" or stopping and saying "Hi" while passing a person in a corridor, depending on whether the conversation with this person is desirable or not [24]. ICQ and similar tools do not provide support for spatial orientation.

In ICQ, it is possible to post different information about yourself, for example contact information, interests, birth date and so on. Nearly the same functionality is available in the @Work system by [32] for a research lab. The Web interface of this system represents a virtual "check-in" board, where the users place information about themselves (plans, phone numbers, in/out, announcements). However, such information does not always provide sufficient awareness about the social structures, relations and memberships, as well as activities and roles, something that appears in our empirical study.

E-mail provides even less functionality in this context, and the reason for it being more used for acquiring social awareness than for example ICQ seems to be that it is the tools students are most used to.

Awareness can also be supported by portable personal devices, such as mobile phones and PDAs [21], so that users can receive notifications of various kind about the status and ongoing activities of other users. This approach provides mostly information about the social situation at the moment and requires more effort than just "taking a glance" at the people around or the user list.

For the purposes of information sharing, many students use BSCW in their daily activities. According to [12], the awareness mechanisms in BSCW are very specialized for writing a document in a small group. It is very difficult to use these awareness mechanisms to gain awareness of activities of larger groups involving a larger number of folder and files. In addition, research shows [29] that human cognition and memory is essentially 3D, so according to [17] "it seems likely that one needs the full 3D sense for the spatial memory to be effective, and would provide 3D virtual environments with a distinct advantage over the lighter weight 2D and textual shared spaces" so the structuring of information could be more effective in 3D environments than in traditional applications".

AWARENESS MECHANISMS IN CVES

Awareness in a virtual community is supported by establishing human contact and providing evidence of presence in a virtual space. The social activities of the users in online communities should be supported in following ways [36]:

- Representing the extent of the space
- Representing the possibilities of particular places within the space
- Showing the presence of individuals
- Allowing activities of individuals to affect the appearance or the structure of the space
- Offering social translucence (implying visibility, awareness and accountability [9]).

According to this, the central elements in social activities in a virtual community are individuals and the space where the social activities take place. In addition, according to [34], social activities and communication are mediated by tools. Therefore, it appears natural to characterize collaborative virtual environments in terms of users, mediating artifacts and space, which provides a container for the artifacts, user embodiments and the social events [28]. We argue that also the awareness mechanisms offered by CVEs can be classified according to this framework. In the following subchapters we will therefore list the basic awareness mechanisms typical of CVEs and then provide an overview of high-level awareness mechanisms in the context of learning communities, according to the characterization framework we have chosen.

Basic awareness mechanisms in CVEs

CVE applications are based on the same general mechanisms as other CSCW applications, but because of their special nature, they have an additional set of basic mechanisms, especially in 3D CVEs. Greenhalgh in [11] classifies awareness management in terms of granularity and form. The items of granularity are the virtual world, the regions within it and artifacts. The author also mentions following basic forms of managing awareness:

- Disjoint membership: the environment is divided in disjoint units, such as every member of each unit is aware of all other members of the same unit, but not of members of other units.
- Topological distance: this approach requires that a topological relationship is established between different units of awareness management, for example links between artifacts.
- Line of sight: applicable to graphical environments and derives from architectural walk-through.
- K-nearest neighbors: the awareness is limited to a specified number of neighboring units
- Explicit model of awareness: a potential range of approaches based on explicit reasoning about awareness, including effects of context and medium. An example is spatial model of interaction proposed by [2].
- Area of interest or aura: a participant's awareness or interest is modeled as a volume of virtual space relative to their momentary position and orientation. Benford et al in [2] suggests introducing additional subspaces: focus and nimbus. The more an object is in your focus, the more aware you are of it. The more an object is within your nimbus, the more aware it is of you. Aura, focus and nimbus, and then awareness are manipulated by objects to manage interactions. They can be manipulated by movement, orientation, explicitly by changing key parameters and through so-called adapter-objects. Aura, focus and nimbus can also be manipulated through boundaries in space. Boundaries provide mechanisms for marking territory, controlling movement and for influencing the interactional properties of space.

High-level awareness mechanisms in CVEs

Space

The notion of space is important for social awareness support for two main reasons. First, the world and region are units of awareness management, and many of the mentioned basic awareness mechanisms are tied to space, such as aura, line of sight and k-nearest neighbor. Second, space has an important social function and provides a background for social events, user embodiments and artifacts [28].

The first group of awareness mechanisms includes those that apply to the "open landscape", such as line of sight. These mechanisms allow the user to have the overview over the events in the intermediate neighborhood, within the "line of horizon" and are usually and integral part of the CVE system used. These mechanisms mimic the analogues mechanisms in the real world.

In the second group we find the ways of creating awareness by structuring the space. By the structure we understand the mutual relations between different parts of the virtual environment, for example the mutual position of "rooms" within a virtual campus or the spatial organization of buildings in a 3D world. The structure can be predefined or might be created and modified by the users. For example, the students make their own rooms with a number of objects and links contained there, added to the global system of campus in 2D (the LambdaMOO environment of the Virtual Campus [22]) or in 3D (Euroland, AvtiveWorlds [1, 31]). In this way, the activities of users can influence the appearance and the structure of the space, providing visualization, or perceptualization of awareness [30] of the social structures and the activities themselves. Space can be structured both physically and topologically, providing different possibilities for awareness management. The awareness is generally propagated by the mechanism of the environmental feedback.

To summarize, the space in CVEs contributes to supporting social awareness in education:

- Space enhances awareness of who is around and what is up in a class, working group or community by providing for chance encounters and communication negotiation similar to what students can experience in physical shared spaces.
- Space provides an arena where the mutual positions and orientations of the students provide awareness of their availability and mutual social relations.
- Space provides the awareness on the ongoing activities, both social and educational, as these activities leave their traces in the space and form it (Euroland project, [31]).
- Space structure visualizes the existing social structures and power relations in learning group and community (as shown in the DomeCity MOO experiment [26]) for example by showing the borders between different group areas.

User

Starting from the definitions of [6], we conclude that the user in CVEs is constructed along dimensions of presence, embodiment and identity.

As we mentioned before, in order to support awareness in a virtual community, the system should provide indication about the presence of the individuals and visibility of individuals and their actions. Witmer et al in [33] defines presence as "the subjective experience for being in one place

or environment, even when one is physically situated in another". Hindmarsh et al in [15] distinguishes between personal, social and environmental presence. Personal presence is defined as the extent to which one feels as if they are in a virtual world [15], with the following components determining engagement in the environment: view, action point and the position in the environment [4]. All these components are connected to the person's aura, i.e. what he can see and be aware of, as well as their region belonging and the people in the immediate neighborhood. The sense of social presence, on the other hand is defined as the extent to which other beings in the world appear to exist and react to the user [15]. The basic sense of social presence in most virtual environments is supported by for example providing a list of persons online (textually) and a group of avatars (visually), therefore indicating the persons present in the various regions of awareness. An additional dimension of social presence are the mutual distances (both immediate and topological ones) between users' avatars, their position, orientation and grouping, due to the fact that the social behavior in CVE resembles that in real life [19]. Less important in the context of social awareness is environmental presence, which is the extent to which the user feels that the environment appears knowledgeable of their avatar's actions [15] since it mostly depends on the technical possibilities of the system. This knowledgeability is often shown as feedback to the user's actions, for example animation of user's interactions with the environment [5].

In order to make others and themselves aware of their presence in a virtual space, users must have a representation or embodiment [23]. Dickey in [6] considers a number of issues in connection with analysis of how embodiment is supported in various virtual worlds: choice of avatars, emotional expressiveness, and navigational and observational possibilities. The appearance of avatars can to a certain degree mimic students' appearance in the real life, clothes and make-up, which serve as indicator of status, occupation etc. The body language like gestures and body postures, facial expression, direction of gaze etc, which is an important part of human communication in the physical world [27], can also be partly reproduced in CVEs, for example by providing a repertoire of predefined gestures. Depending on the embodiment chosen, the user can have different possibilities for navigation and observation in the environment, but this is also up to the existing space structures. In most virtual worlds users can navigate by pressing the arrow buttons on the keyboard or manipulating the mouse, to move into new rooms and spaces or make the avatar turn and move in the right direction. In additional to the movement analogous to that in real life, the user can move along the topological ties in the space, for example following a link. In some systems the user is capable of observing the world from the 3rd person perspective, as well viewing different parts of the world from various altitudes, zooming in- and out parts of the world, or acquire individually tailored views [20].

It is impossible to achieve an unambiguous representation of user without introducing the notion of identity. It is often tied to a user nick or an avatar, though some systems like ActiveWorlds [1] assign a unique number to each user, since the avatars are not unique. The identity is often associated with a reputation, a circle of acquaintances, a place in the social hierarchy in the virtual world [18]. Identity is tightly coupled to the objects or artifacts the user creates, for example as in Active Worlds.

The awareness on the "user" level is achieved by the generic awareness mechanisms such as direct and consequential communication and indirect productions and, in some cases by feedthrough where there is a direct relation between user and his artifacts. To summarize, the user dimension provides following mechanisms for supporting social awareness in educational context:

- Students can produce and attain awareness of the each other interests, levels of knowledge, group and community memberships, relations and roles by choice of embodiment, degree of presence and identity (choice of avatar, spatial position and orientation etc).
- The sense of presence and embodiment also provide the social awareness of the moment, i.e. who is around, what they are doing, the emotional expressions etc (chat, gestures, orientation).
- Students can create their identity through a history of communications and contacts, as well as created artifacts and thus provide awareness about their personality, place in the local social structures and resources possessed by them.
- By choosing appropriate embodiment the students can easily move between different awareness regions and items of granularity and provide the overview unattainable in the real world.

Artifacts

An important aspect of interacting in the CVE is the manipulation of objects or artifacts. The objects can be everything from whiteboards, 3D models of human body to documents and virtual furniture. In general, we define artifacts as units, created and modified by users for the purpose of communication facilitation and task accomplishing.

When artifacts are shared, they become both the subject and the medium for communication [28]. An artifact serves the communicational purposes by providing information about the actions performed on it and the identity of the person performing the actions. The joint use of artifacts needs coordination. Hindmarsh in [16] mentions shared view and user embodiment as possible coordination mechanisms in CVEs, connecting together the users, the place and the artifacts in one awareness management framework:

- The shared view of the common virtual world allows access the shared artifacts, even though the users are separated by physical distances.

- The embodiment of users provides the awareness of users' actions and manipulations of the shared artifacts.

The artifact is the smallest unit of awareness management, with all the basic awareness management forms appliable to it. Artifacts can provide awareness information in different ways. For example, the users can observe the modification of the artifact directly, either in real time (animation of other users' actions on artefact, pointers with the name of the modifier, highlighting etc) or post factum, by reflecting on the change in the parameters (position, colour etc). In addition to the information on how the artifact is changed, it is important to know who did it. This information can be provided directly by observing avatars or other representations of users performing actions on objects or leaving records on the artifact with the information on who changed it and when. Artifacts also can serve as transfer node between different awareness region and spatial structures, by for example containing hyperlinks. The awareness is propagated through mechanisms of feedthrough and environmental feedback.

The artifacts can therefore provide social awareness in a learing community in following ways:

- By reflecting the status and identity of the students who own or change the artefact (for example, user number on the artefact, the appearance of artefact)
- By revealing knowledge and skills the owner posesses (text, pictures, links put on the artefact)
- By reflecting activities performed by the students
- By revealing the social structure around and membership (whos area it is located on, what links it contains, what people collaborated on it)

CONCLUSIONS

We have looked at the mechanisms for supporting social awareness in the natural environments such as the shared workplace, traditional technical tools such as ICQ, e-mail and mobiles, and the mechanisms offered by collaborative virtual environments. We can conclude that the mechanisms offered by the natural environment of university, even supplemented by the usual technical tools, are not enough. We can also conclude that the mechanisms offered by CVEs provide a promising supplement to the mechanisms and tools already in use in the educational context. This is true for a number of reasons: first, CVEs present in some way a copy of the real world, so the awareness mechanisms available in CVEs are more similar to those people use in the real life, and that extraction of cues will be more natural and easy then in the tools that only provide abstract cues. Second, the structure of the university locations in the real life, as well as the artifacts available and the students' ways of expressing themselves, do not always facilitate the extraction of the social cues in the most effective way, as shown in our study so it is necessary to provide an alternative space, artifacts and user representation with the functionality unattainable in the real world. Since the students fail to achieve enough awareness of the complex phenomena such as group dynamics and community structure by using natural mechanisms and traditional tools, it is necessary to provide alternative ways of visualizing and presenting them, for example by building virtual places and objects.

Our goal in the future will be to develop a virtual system that will provide an effective support for social awareness among university students.

ACKNOWLEDGEMENTS

The research reported here is financed by the Norwegian Research Council in the context of the project CAGIS II. Special thanks to Monica Divitini for valuable comments and feedbacks.

REFERENCES

[1] Active Worlds: www.activeworlds.com
[2] Benford, S., Bowers, J., Fahlen, L.E. and Greenhalgh, C. "Managing Mutual Awareness in Collaborative Virtual Environments." *In Proceedings VRST 1994, ACM Press.*
[3] Bogdan, C., Sundblad, O. "A Cue-based, Integrated System for Supporting Social Awareness." *Report, CID*, 1999.
[4] Buscher, M., O'Brien, J., Rodden, T., and Trevor, J. "He's Behind You": The Experience of Presence in Shared Virtual Environments." In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments.* Chapter 5, Springer-Verlag London Limited, 2001.
[5] Cuddiny, E., Walters, D. "Embodied Interaction in Social Virtual Environments". *In Proceedings of CVE 2000.*
[6] Dickey, M. D. "3D Virtual Worlds and Learning: An Analysis of the Impact of Design Affordances and Limitations in Active Worlds, Blaxxun Interactive, and Onlive! Traveler; and a Study of the Implementation of Active Worlds for Formal and Informal Education". *Dissertation*. The Ohio State University, 1999.
[7] Dourish, P., Bellotti, V. "Awareness and Coordination in Shared Workspaces". *In proceedings CSCW 1992.*
[8] Engestrom, Y. "Learning by Expanding: An Activity-Theoretical Approach to Developmental Research." *Helsinki: Orienta-Konsultit*, 1978.
[9] Erickson, T., Kellogg, W. "Social Translucence: An Approach to Designing Systems that Support Social Processes". *ACM Transaction on Computer-Human Interaction*, Vol 7, No 1, March 2000, Pages 59-83.
[10] Goldman, S. V. "Computer Resources for Supporting Student Conversations about Science Concepts". *SIGCUE Outlook*, 1992, 21(3), p4-7.
[11] Greenhalgh, C. "Analysing Awareness Management in Distributed Virtual Environments." *In Proceedings of 2nd Annual Workshop on System Aspects of Sharing a Virtual Reality*, CVE, 1998
[12] Farshchian, B. A. and Divitini, M. "A product-Centered Approach to support Learning Communities". *In Proceedings of i3 workshop on learning communities*, 2000
[13] Gutwin, C., Greenberg, S., Roseman, M. "Workspace Awareness in Real-Time Distributed Groupware: Framework, Widgets and Evaluation." *In proceedings of HCI 1996*.
[14] Gutwin, C., Stark, G., Greenberg, S. "Support for Workspace Awareness in Educational Groupware". *In proceedings of CSCL 1995*.

[15] Hindmarsh, J., Fraser, M., Heath, C., Benford, S., Greenhalg, C. "Fragmented Interaction: Establishing mutual orientation in virtual environments". *In Proceedings of CSCW 1998.*

[16] Hindmarsh, J., Fraser, M., Heath, C., and Benford, S. "Virtually Missing the Point: Configuring CVEs for Object-Focused Interaction". In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments*. Chapter 7, Springer-Verlag London Limited, 2001.

[17] Huxor, A. "The Role of the Personal in Social Workspaces: Reflection on Working in AlphaWorld". In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments*. Chapter 15, Springer-Verlag London Limited, 2001.

[18] Jakobsson, M. "Rest in Peace, Bill the Bot: Death and Life in Virtual Worlds." *The Social Life of Avatars.* Springer-Verlag London Ltd. 2002.

[19] Jeffrey, P. & Mark, G. "Navigating the Virtual Landscape: Co-ordinating the Shared Use of Space". In Munro, A., Hook, K., and Beynon, D. (Eds). *Social Navigation of Information Space.* London: Springer, Chapter 7.

[20] Jåå-Aro, K., and Snowdown, D. "How Not to be Objective". In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments*. Chapter 8, Springer-Verlag London Limited, 2001.

[21] Liechti, O., Sifer, M., Ichikawa, T. "Supporting Social Awareness on the World Wide Web With the Handheld CyberWindow." *In proceedings of Workshop on Awareness, CSCW 2000*.

[22] Maher, M. "Designing the Virtual Campus as a Virtual World". *In proceedings of CSCL 1999.*

[23] Mania, K., Chalmers, A. "A Classification for User Embodiment in Collaborative Virtual Environments". *"In Proceedings of the 4th International conference on Virtual Systems and Multimedia*, 1998

[24] McGrath, A, Prinz, W. "All That is Solid Melts Into Software". In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments*. Chapter 6 Springer-Verlag London Limited, 2001.

[25] Prinz., W. "NESSIE: An Awareness Environment for Cooperative Settings". *In proceedings of CSCW 1999*.

[26] Rayborn., E. M. "Designing an Emergent Culture of Negotiation in Collaborative Virtual Communities: The DomeCityMoo Simulation". *Collaborative Virtual Environments*. Springer-Verlag London Ltd, 2001.

[27] Salem, B., Earle, N. "Designing a Non-Verbal Language for Expressive Avatars". *In Proceedings of CVE 2000.*

[28] Snowdown, D., Churchill, E. F., and Munro, A. J. "Collaborative Virtual Environments: Digital Spaces and Places for CSCW: An Introduction." In Churchill, E. F., Snowdown, D. N., and Munro, A. J. (Eds.) *Collaborative Virtual Environments*. Chapter 15, Springer-Verlag London Limited, 2001.

[29] Spence, J. D. "The Memory of Palaceof Matteo Ricci." New York: Viking Penguin, 1984.

[30] Sohlenkamp, M "Supporting Group Awareness in Multi-User Environments through Perceptualization". *PhD dissertation*, 1999.

[31] Talamo, A., Ligorio, M. B. "Identity in the Cyberspace: The Social Construction of Identity Through On-Line Virtual Interactions". *In Proceedings of 1st Dialogical Self Conference,* 2000.

[32] Tollmar, K., Sandor, O., Schomer, A. "Supporting Social Awareness. @Work Design and Experience". *In proceedings of CSCW 1996*.

[33] Witmer, B., Singer, M. "Measuring Presence in Virtual Environments: A Presence Questionnaire". 1998.

[34] Vygotsky, L. "Mind in Society: The development of Higher Order Psychological Processes". Cambridge, MA:Harvard University Press, 1978.

[35] Wenger, E. "Communities of Practice:Learning, Meaning,and Identity:" Cambridge University Press, 1999.

[36] Wolf, T. "Creating Virtual Places for Community Involvement." *In proceedings of Workshop on Awareness,* CSCW 2000.