Participatory Design and Communication in Virtual Environments

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ABSTRACT
There are numerous approaches and techniques for establishing a virtual environment for participatory design. The most common approach is to extend the personal computer desktop environment to include tools for meeting and sharing files and making those files available to all those involved in the design development. This approach takes the individual work environment and adds tools for communicating with others. An alternative approach is to create a virtual world environment in which the design team meets, works, and organises the project information and models. This approach differs conceptually because it creates a sense of place that is unique to the project, sort of a shared office space. The variation in the environment effects the way in which the design ideas are communicated. We highlight the differences in communicating by talking or typing.

1. INTRODUCTION

Most design projects incorporate some collection of computer-based tools for handling electronic documents and communication. Following the traditional office paradigm large amounts of project data files (such as drawings, documents, spreadsheets, databases, manuals, forms, communications, schedules and discussions) move around the design office from one computer workplace to another, where they are processed on the individual designer's "desktop". The use of file server technology is usually reduced to the most rudimentary operations of moving files from one shared disk to another. Sometimes the same information is unnecessarily duplicated, sometimes important files remain either locked on the personal computer or lost somewhere on a barely navigable list of shared directories on a file server. The use of computer environments for collaborative design does not always result in more collaboration, possibly because the focus is on making the files available rather than on creating an environment in which people can work together.

We have developed and experimented with designers using virtual environments (Maher, Simoff, and Cicognani, 2000; Maher, Cicognani, and Simoff, 1997; Gabriel and Maher, 1999a and b), which we refer to as virtual design studios. These experiments indicate that the type of environment influences the type of communication. For example, when using a video conference environment and a shared whiteboard, designers tend to create drawings that were harder to comprehend than the same designers created when working alone using the same software (Maher, Cicognani, and Simoff, 1997). We also found that designers collaborating in a virtual room using a "talk by typing" method demonstrated more brainstorming activity than designers using a video conference with an audio link for talking (Gabriel and Maher, 1999).

To explore environments for collaborative and participatory design, we consider two types of virtual design environments. One environment is an extension of the personal desktop tools; the second is the development of a virtual place. Different metaphors can provide the conceptual basis for the development and use of a virtual environment for participatory design. For example, the virtual design environment can build on the desktop metaphor, popular in computer operating systems, or the metaphor of place can shape the way in which designers work together.

To better understand how different environments affect communication in a participatory design session, we analyse the discussion that takes place in different virtual environments using a coding scheme. The coding scheme categorises the content of the discussion broadly into communication issues and design issues. The coded discussion then provides some insight into to the way in which environments influence the communication.

2. DESKTOP VS PLACE

The desktop metaphor refers to the use of collaborative tools as if they were lying on a working desk of a physical office. On the desktop, and nearby, a designer finds tools for drawing and authoring (eg. pencils, rulers, paper), communicating (eg. telephone), archiving (eg. folders, filing cabinets), organising (eg. diary), finding

information (eg. catalogues, archives), and so on. In general, she has access to all the office resources to perform the design task. On the electronic desktop – which is based on a metaphor of the physical one - all the functions are collected on the same interface, in this case, visible on the computer screen. This approach is the most common and is presented as the "toolkit approach" in Lin and Protzen (1997).

Using the desktop metaphor, each personal computer has a set of tools, as each personal desk has its own set of tools. Integration, in order to enable collaboration, involves determining a compatible set of tools so that information can be transferred from one computer to another. The integration of communication technologies, project management, and design documentation can be realised in several ways - through the core of Web technology, an office suite style integration, or the custom development of design software (Maher, Simoff and Cicognani, 2000).

Communication in a desktop environment can be synchronous or asynchronous. The support for asynchronous communication is provided by tools for sending messages, such as email, bulletin boards, list servers, and by tools for sharing files, such as web servers and ftp hosts. The support for synchronous communication often emulates the physical equivalent, such as an audio link to emulate a phone conversation and a video conference to emulate a meeting. Using these tools, the participants in the design session can see and hear each other even though they are not in the same physical office.

Virtual place, which includes virtual worlds and virtual reality applications, can be defined as a single computer-mediated dynamic environment that: (i) is based on a world model (or world metaphor), (ii) creates a sense of "place", regardless of the underlying computing architecture, (iii) is shared by multiple participants connected from different hosts. The Internet has been accommodating more than a dozen different technologies supporting multi-user text-based, and two- and three-dimensional graphical virtual worlds. When adopting the place metaphor, preparing a virtual design environment is more like designing a physical office than developing an organisation for a desktop.

One aspect of the virtual place metaphor is the establishment of the identity of the people in the place. In a physical studio, a person's appearance, personality, and knowledge become known through their interaction with others in the studio. This also occurs in a virtual place through the representation of individuals as an avatar or object ('character[1]') that has various properties. An 'avatar[2]' (Damer, 1998) is a 3D model of the person and shows where they are, where they are looking, and what gestures they want to communicate. Object representations of a person include characteristics such as a verbal description, messages about their movements in the place, and links to web pages and publications help establish their identity and personality. The visual presence of the avatars brings a new dimension in communication in virtual places.

There are two aspects to developing a virtual design environment based on the place metaphor: the development of a virtual design office and the phenomena of "designing in the design". The virtual design office is a virtual place with spatial characteristics. We have pursued this idea by developing a virtual design office in Active Worlds [3]. Active Worlds provides computing support for the place metaphor, which includes two layers - a central universe server which runs one or more object-oriented world models. Worlds may reside on different hosts, implementing the idea of "place" metaphor over distributed computing architecture. Active Worlds provides an Internet based browser that allows users to navigate through the environments of various virtual worlds. From the CSCW perspective Active Worlds offers a collaborative environment for integrated access to 3D- and 2D digital media representations. A person, represented as an avatar, can contribute by adding new building objects, linking them with Web pages and can talk to others in the 3D world by typing.

In Figure 1 we show the virtual design office developed as part of our project, and described in (Hong, 1999). The office is located within the 3D-modelling environment and includes a meeting room in the centre, with a walking area around the meeting room for viewing the development of the 3D models for various projects. The workspace environment includes also asynchronous and synchronous communication areas, and a Web information area.

The virtual design environment can also include a model of the product being designed. Although this is a relatively new approach, Woo, Lee, and Sasada (1999) show how such an immersive 3D environment can be used to evaluate design alternatives. The major feature of this kind of environment is the development of the design within the collaborative, multi-user environment. Designers can work alone or collaboratively building a design model and discussing the design as they view the model. There is only one representation of the model so there isn't a problem with simultaneous changes to different versions. There is a continuum of the process – a person does not shift environments when designing alone

[1] 'Character' as a term is used in text-based virtual worlds.

[2] Avatar is an ancient Sanskrit term meaning 'a god's embodiment on the Earth' (Damer, 1998).

[3] http://www.activeworlds.com

or collaboratively, and there is a continuum of the workspace during the design session - all working information about the design is accessed and shared through the same environment.

Figure 1. A virtual design office

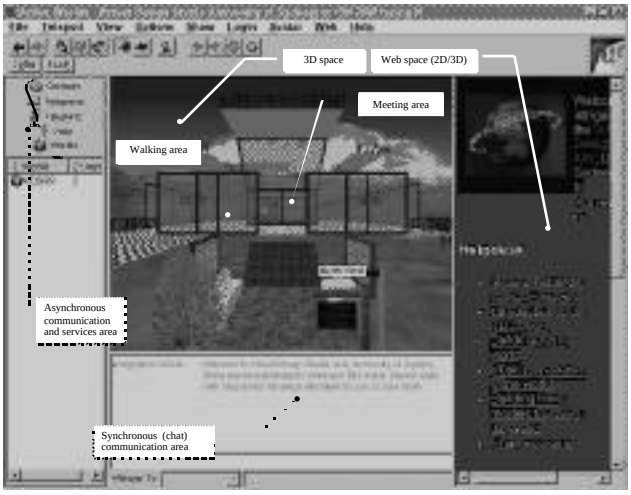


Figure 2 shows a design project in which the 3D model became the meeting place for the design team. The project involved the design of a building for the Global Learning Centre at Stanford University (Maher and Simoff, 2000). The design team consisted of graduate students in the Virtual Architecture course in the Faculty of Architecture at the University of Sydney, with a group of people at Stanford as the clients. The students were given a design brief outlining the intended use of the building, emphasising the requirement for flexible use of space. The students were also given a description of the existing building that would be modified for the new use as a Global Learning Centre. Materials for the project, design representations and documentation were kept and accessed only in electronic form. Figure 2 illustrates the utilisation of the 3D/2D information integration in CSCW activities performed in this environment.

There are number of features that characterise the "design within the design". One is the spatial organisation of the objects on the design site. Designers organised the design objects on the site, introducing simultaneously the spatial relations between the objects and between the designers and the objects. The objects may not necessarily represent building design objects - for instance, similar picture can be observed in a virtual world for designing computer programs where computing modules are represented in a Lego-style blocks. The second feature is connected with populating the design site. Having an avatar representation of each designer "within the design", each person is aware of the presence and to some extent about the activities of the others, as shown in Figure 3. Collaborators can see and interpret each other's actions, can discuss design ideas with each other, and see where the others are looking. Communication in the 3D design environment relies to a certain extent on visual contact with others in the virtual place through the avatars. Although the discussion is seen in a chat-like window where people "talk by typing", the latest phrase can be displayed in the space surrounding the avatar, so the other participants receive visual cues about who is talking.

Figure 2. The Stanford project design site.

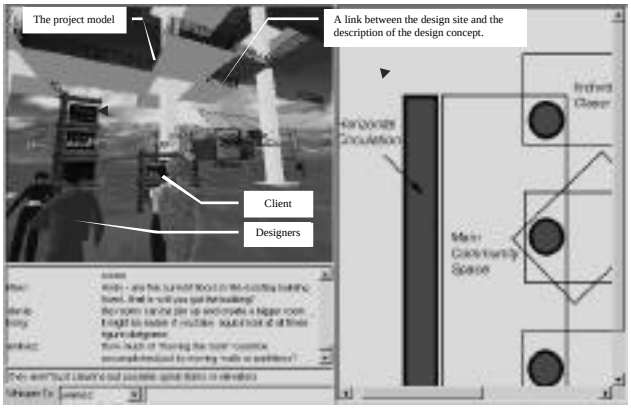
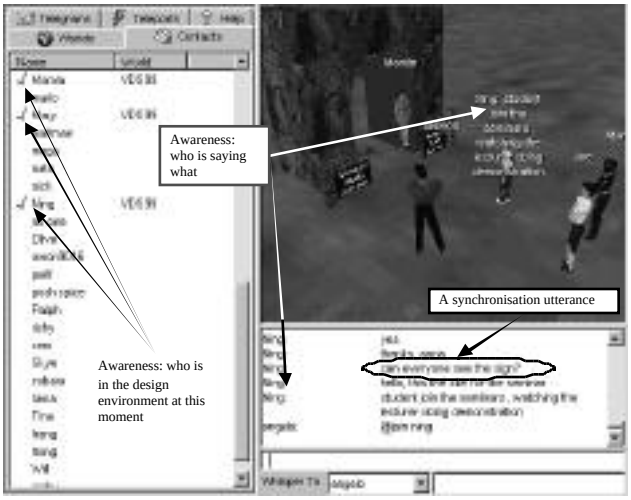


Figure 3. "Populating" the design place.



3. COMMUNICATION IN PARTICIPATORY DESIGN IN VIRTUAL ENVIRONMENTS

In order to analyse communication in different virtual design environments, we considered four different coding schemes used in studies of computer-mediated communication and cognitive studies of designers. The first, (See Sudweeks and Albritton, 1996) categorises communication types as follows: Informal control of communication, formal control of communication, socio-emotional communication, conceptual communication, task communication. The second coding scheme investigates the amount of time spent in computer mediated collaborative sessions ‘introducing new ideas and clarifying those ideas’ (See Olson et al., 1997). The third coding scheme on the other hand classifies interaction between FTF and Video-conferencing technologies by investigating ‘Interruptions, overlaps, hand-overs and dominance’ (See O'Connail and Whittaker, 1997). Part of the fourth coding scheme

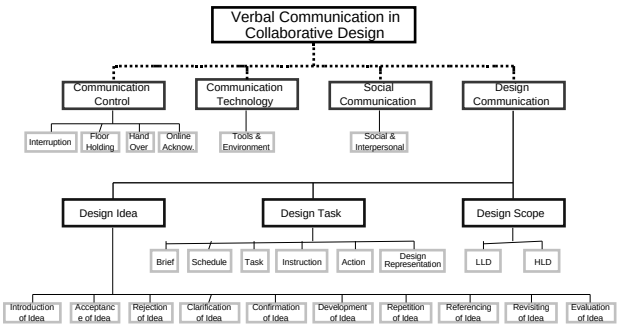
investigated 'low level design' versus 'high level design' in computer mediated design sessions with full and limited communication channels (For more details see Vera et al., 1998).

We customised a coding scheme specifically to study the difference in designing using a video conference type facility as a typical "desktop" approach and using a virtual place environment. The coding scheme is made up of four major classifications and in turn some of these are further broken down into sub-categories, illustrated in Figure 4. These classifications are:

1. *'Communication control'*, a category which would help identify differences in how much of the design session was focussed on maintaining the floor, handing over control to another person, interruptions, and acknowledging presence.
2. *'Communication technology'*, a category which looks at discussions held between participants related to the use of the tools and the collaborative environment.
3. *'Social communication'*, a category which looks at the amount of time spent in social talk.
4. *'Design communication'*, a category which first characterises the discussion in terms of 'design ideas', 'design scope' and 'design task'. Within each of these categories, the coding scheme distinguishes different activities in communicating design ideas, the differences and the scope of the discussion, and the time spent organising the design tasks. For a more detailed account see (Gabriel and Maher, 1999).

These categories are not intended to be exhaustive, but to indicate, through analysis, the relative amounts of communication in each category. We are particularly interested in whether the type of virtual environment affects the discussion of design content, and whether there are significant differences in the way communication control occurs in the different collaborative environments. The categories are not exclusive, a single statement could be classified in more than one category.

Figure 4. A hierarchical tree of the coding scheme.



4. ANALYSIS OF COMMUNICATION IN VIRTUAL DESIGN ENVIRONMENTS

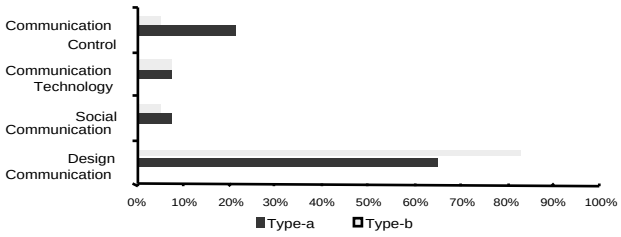
Here we present an analysis of the discussions in two experiments:

1. Experiment 1: An experiment to compare "talking" with "talking by typing". In this experiment we analysed and compared the discussion of 8 pairs of designers working together using a video conference facility in which they can talk to each other while looking at the design in a shared window, and 8 pairs of designers working together in a virtual room in which they talk by typing while looking at the design.
2. Experiment 2: An experiment to analyse the discussion in participatory design sessions of a longer project during which the design team presented a conceptual design to the clients. The sessions took place in a 3D virtual world in which the participants could see each other as avatars and could talk by typing.

We present experiment 1 briefly here. A more extensive description of this experiment is given in (Gabriel, 2000). We highlight the major findings in experiment 1 as a basis for extending the coding scheme and comparing the results in experiment 2.

In experiment 1, we refer to the environment in which the designers used a video conference facility as type-a and the environment in which the designers used a virtual room as type-b. The virtual room in environment type-b was part of our virtual campus (Maher, 1999) built in lambdaMOO. In both environments, the designers used a shared drawing board in addition to the talking facilities. A summary of the results of the discussion in the four major categories is shown in Figure 5. The designers using the type-a environment, with a greater percentage of time in communication control, often interrupted each other, talked constantly, and more spontaneously. With no interruptions the designers using the type-b environment spent a significant amount of time communicating their design ideas as if they were designing by themselves, and taking more time to think about their typed communication before sending it to the other designer. They introduced a large number of new design ideas when compared to the designers using the type-a environment in the same amount of time on the same design problem. Through the talk-by-typing interaction, the designers introduced ideas by recording them in writing. This allowed them to revisit introduced ideas, if and whenever the need arose, to either develop them further, refresh their memories or discard them.

Figure 5. The average percentage of utterances in the major categories in Experiment 1.



In experiment 2, we focussed more on participatory

design, where the design team included more than two designers. We distinguish two types of participatory design sessions: with and without the client. We extended the coding scheme, presented in Figure 3 with two categories - Communication modality, with "Addressing all" and "Addressing individual" as subcategories, to capture dynamics within a team; and Communication for Orientation, to capture the interactions related to orientation within the information during a participatory session (including the navigation and orientation within the environment and different design representations). Another modification of the original coding schema, is the addition of "Synchronisation" as a subcategory of the Communication control category, which depicts moments of synchronisation of the focus of all designers of the team (for example, "Can everyone see the concept drawing?").

The sessions, with and without the client, analysed in this case study have 176 and 466 utterances, respectively. The diagram in Figure 6 shows that the participatory design sessions are characterised by a high proportion of design communication with respect to the other communication categories. The dominant category in the design communication, as illustrated by the diagram in Figure 7a, is the communication of design ideas, combined with high-level (conceptual) design decisions. Gabriel and Maher (1999b) observed similar results in their type-b session where designers used text based communication. To some extent this means that the 3D presence within the design does not decrease the intensity and concentration of text-based communication, identified by Gabriel and Maher (1999b). The higher percentage of task management communication may be due to the teamwork and the length of the design project in comparison with the one-hour duration of experiment 1.

Figure 6. The average percentage of utterances in the major categories in Experiment 2.

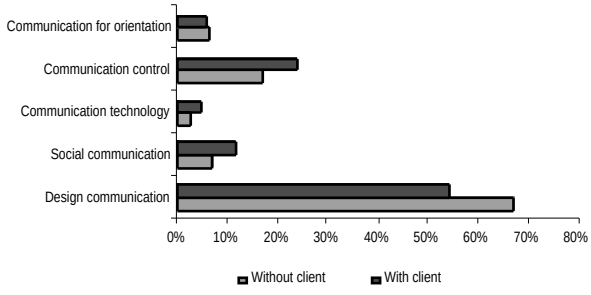
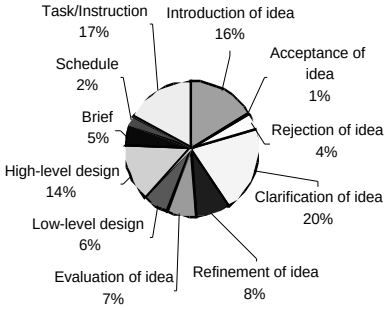
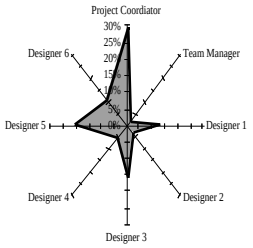


Figure 7. Categories and amounts of participatory communication in team meeting

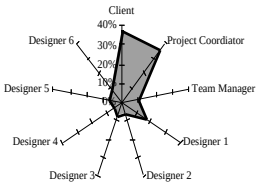
a. Design communication



b. Participation (without the client)



c. Participation (with the client)



The diagrams in Figure 7b and c present the patterns of individual participation in the participatory sessions without (session 1) and with the client (session 2). Participation is estimated based on the number utterances in all categories, except "Social communication" (for details about the methodology see Simoff and Maher (2000)). Both sessions were connected with conceptual design. In the first session, participants were developing the conceptual design based on the available design descriptions and requirements. In the second session, the design concepts were revised and reinterpreted based on the presentation of the initial design against the design brief and the feedback provided by the client. The patterns in Figure 7b and c shows that during session 1 designers demonstrated relatively higher relevant activity in comparison to session 2. The pattern can be explained with the 3D presence within the design representation, which allowed designers a fairly economical initial presentation of the design concepts in the communication transcripts, relying on short references and visual cues. Client phrases like "Do we need to go somewhere to view the concept as you describe it?" (classified in the category "Communication for orientation" in Figure 6) and "Trying to absorb things we're seeing for the first time... :-)" give an idea about the process itself. The extensive

participation of the client not only in the evaluation, but actually in the design itself and the refinement of the requirements explains the high percentage of client activities in Figure 7c.

The dynamics of design communication during the design session (session 1) is shown in Figure 8 and Figure 9. These graphs represent parallel timelines (each time point corresponds to an utterance) for each category of design communication. The graph in Figure 8 shows that conceptual participatory design is characterised with fairly intensive introduction and clarification of ideas during almost the whole session. The fairly low final acceptance and rejection of ideas can be explained by the quick visualisation and illustration of the concepts in the 3D design environment. Figure 8 shows that the design communication at the end of the session was focussed on task management (this communication pattern was observed in both sessions).

Figure 8. Communication of design ideas during the session.

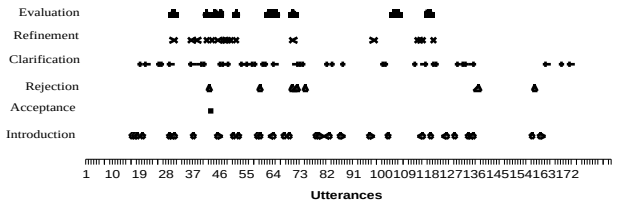
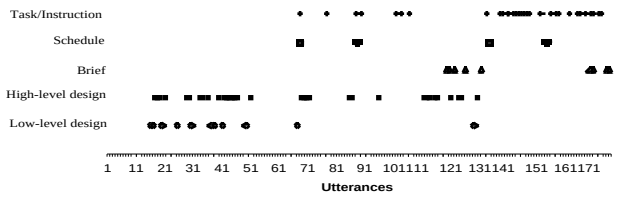


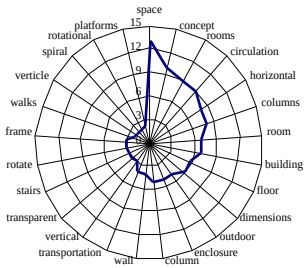
Figure 9. Communication relevant to the design scope and tasks.



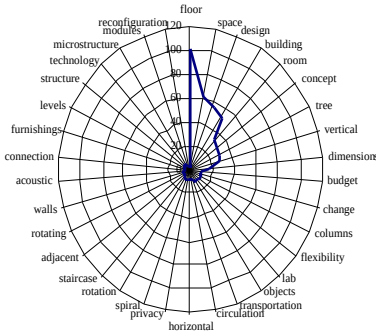
In addition to coding the types of communication, we considered the distribution of communication content by performing a text analysis of the transcript. The major focus of the design team in session 1 was on the concept of a light construct with enhanced circulation. The list of most frequently used concepts, shown in Figure 10, demonstrates that despite the extensive visualisation in terms of geometrical forms, designers need to explain and refine the semantics of these forms. For example, the horizontal circulation caused a major discussion (indicated by the relatively high frequency of related terms), when the idea of the vertical transportation came across fairly easily from the model (indicated by the relatively low frequency of the relevant keywords). During the session with the client the concept of a "floor" became a central issue (see Figure 10b), which changed the overall design concept. During the first session the interpretation of the design requirements illustrate that the concept of a "floor" was less important in comparison to the "circulation" issues (see Figure 10a). The higher values of word frequencies in the second session indicates again that the 3D presence within the design does not decrease the intensity and concentration of text-based communication when it comes to clarification of design ideas.

Figure 10. Key concepts from the sessions

a. without client



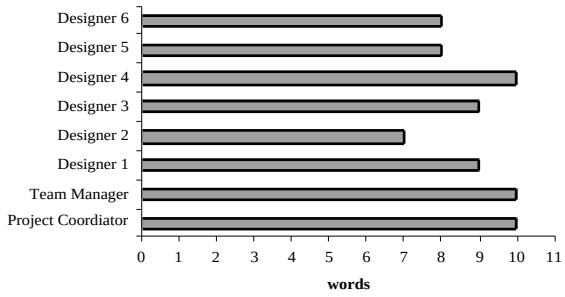
b. with client



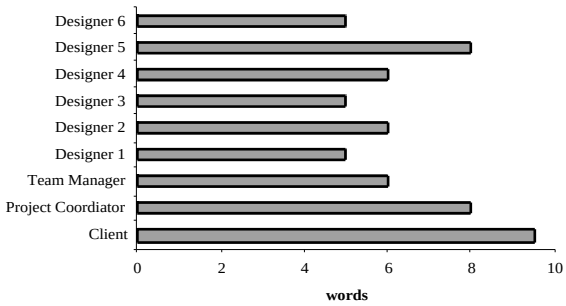
We expected that being within the design would assist to explain design ideas with less words, based on simple references to the objects. This is illustrated by the decrease of the average length of designer's utterances in the session 2 in comparison to the session 1, as shown in Figure 11a and b. The average lengths of designers' utterances are less than a dozen words in the session 1 (see Figure 11a) and they go to less than half a dozen in the session 2 (see Figure 11b). More than a third of the words in an utterance goes to the class of stop words (words that are part of the grammatical form and do not carry semantic meaning). To some extent this supports our initial hypothesis, however, further investigation is required for more rigorous conclusions.

Figure 11. Text statistics of the design session utterances.

a. without client



b. with client



The relatively short length of utterances in sessions in "talking by typing" environments with 3D presence vs the "talking" in experiments 1 series can be explained also with some technological restrictions, connected with the display of avatar speech directly in the 3D scenery. In the case of a longer utterance, the text of the utterance can cover the avatar and the other participants could not see where the avatar is looking, pointing or the gestures that it performs during that moment, as illustrated in Figure 12.

We also considered the threads of conversation during the team meeting (based on the coding in "Communication modality" category and the references in the communication content). Despite relatively short phrases, the communication within the design was fairly focussed. As shown in Figure 7 the first half of the session is characterised by low level of local threads between individual designers. The substantial increase in the individual threads in the middle is an indicator of potential asynchronisation of the design session, correctly detected by the project coordinator. The work of the team had to be synchronised also, when the attention of the designers was divided between the model of the design concept in the virtual world and an external illustration of design concepts (utterances 115-120).

Figure 12. Short utterances are preferable in 3D environments with "talk by typing" communication

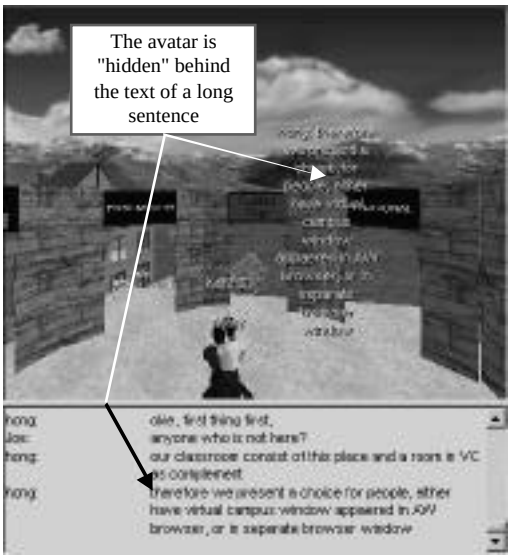
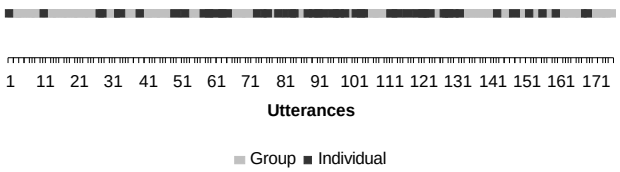


Table 1 shows the correlation between different communication categories in the session 1 (without the client). The results show high correlation between the design communication and communication for orientation category, which explains to some extent the observation that the 3D presence within the design does not decrease the intensity and concentration of text-based communication – a portion of the design communication "migrates" in the communication for orientation. On the other hand, there is no significant correlation between the communication related to technology and any other type of communication in the participatory session, which means that communication of technological issues does not have significant influence on the design communication in such environments.

Table 1. Correlation between categories

	Comm Control	Comm Tech	Social Comm	Comm for Orient	Design Comm
Communication Control	1.00				
Communication Technology	-0.31	1.00			
Social Communication	0.67	-0.22	1.00		
Communication for Orientation	0.65	-0.16	0.77	1.00	
Design Communication	0.78	-0.24	0.64	0.93	1.00

Figure 13. Changes in communication mode during the design session



5. CONCLUSIONS

Designing in a virtual place is substantially different concept from designing using a video conference or desktop environment. The collaborative potential in these types of environment is not well understood. We focus on the communication aspects in the different environments and look for the similarities and differences which may lead to choosing one type of environment over another. Our initial results show that a major difference in communication content and style occurs when comparing a talk by speaking environment to a talk by typing environment. The difference is largely manifested in the lack of interruption while talking by typing. When comparing two talk by typing environments, one in which the presence of others is expressed through avatars in a 3D world and one in which the presence is conveyed only by the words spoken (such as a lamdaMOO environment), indicate that there may be some benefit to communicating and designing in 3D worlds.

We also consider the difference between the visual presence of the participants in the session via video conference and their presence through 3D avatars. The video conferencing communication environment has the notion of the sites involved - whether these are isolated individuals or groups (for example, a conferencing between two studio sites). In this case, it can be considered that the desktop workspace actually has been extended by augmenting parts of the physical environment visible to the conference participants. Usually these are the office environments, so the video conferencing communication introduces another degree of discontinuity. To some extent, in a collaborative session these extensions can be considered as the "background noise" in a telephone conversation. There is particular threshold above which collaborators can not cope with such noise (see Maher, Cicognani and Simoff, 1997). In a design session in a 3D virtual environment the avatars are immersed in the context of the design session (in some cases this context can be the design itself). Thus the "talking by typing" communication in such environments preserves the continuity of the workspace.

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