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Why spatial metaphors are relevant to virtual campuses?

Introduction

A virtual campus is a set of on-line educational resources, organised around a spatial metaphor, i.e. resources are located in different area of the cyberspace. These resources are two-folded:

- On-line sources of information include texts, video and audio documents, bibliographies, computational models, databases, real-time measurements, ... often accessible via World Wide Web.
- Media for interacting with other members of the virtual campus (tutors, students, administrators, ...) include written, voice and video communication tools, synchronous or not: electronic mail, chat boxes, discussion forum, audio links, video channels, ... These media also include shared workspaces where users can jointly manipulate a set of objects (e.g. whiteboards).

A set of resources (a course, a curriculum) can be organised in different ways: as an arborescence of directories and files (tree structure), as a hyperdocument (network structure) or as a real place (rooms connect with corridors, corridors with stairs, building with streets, ...). This spatial metaphor rules the access to both kinds of resources: communication varies across space (e.g. private conversation are bound to all users within the same virtual room), and the structure of information sources reflect some architectural concepts. Obviously, spatial metaphors are afforded by current technologies, and even pushed very far in immersive 3-dimensional virtual worlds (Hagsand, 1996, ...). But does it bring any interesting functionality to the design of on-line educational activities? Does it have any impact on the users behaviour? We address these issues by reporting two studies. The first is a formal experiment on collaborative problem solving in a virtual space, the second reports an experience of virtual campus which started in 1994 at TECFA.

First study: How space supports collaboration

Virtual reality (VR) systems are computerised environments in which the user can move in virtual space (e.g. rooms) and manipulate objects. Virtual collaborative environments (VCEs) are virtual realities with multiple users who act and interact with each other. Each user is represented in the virtual space by an 'avatar'. We conducted research on text-based VCEs called MOO environments. Space is here treated as a social construct rather than from the perceptual standpoint, since the rooms are not described by images, but only by text. We wondered *whether virtual space would actually influence the collaborative process among peers*. The answer is positive and illustrated below in 5 points. This tasks[1] involved 20 pairs solving collaboratively a murder mystery: a guest in an auberge had been killed and the two users played the role of detectives. The two detectives, Hercule and Sherlock, visited the various rooms, asked question to suspects (MOO programmes) and looked at objects, until they found out who had killed the guest.

Space modifies communication patterns

Pairs do not communicate in the same way when they are in the same virtual room or not. When the subjects are in the same room, they acknowledge in average 50 % of utterances versus only 34% when in different rooms[2] ($F(18,1)=9.75$, $p< .05$). Moreover, the delay of acknowledgement is shorter when subjects are in the same room (39 seconds) than when in different rooms (59 seconds) ($F(18,1)=6.56$, $p= .015$)[3]. The shorter delay might indicate a tendency to give shorter answers when

1. http://tecfa.unige.ch/tecfa/research/cscps/bootnap.html
2. We counted the rate of acknowledgement as the percentage of utterances being answered by the partner. Acknowledgement goes from elementary back-channel messages (such as "uh huh" up touh huh") up to elaborated answers, rephrasing, counter-arguments and so forth.

people talk in the same room. This was however not the case: the average length of 'say' (local talk) and 'page' (remote talk) messages was almost identical (respectively 46.8 and 48.8 characters per message). These findings can be interpreted in two ways:

- One interpretation is that some feeling of copresence exists in a virtual space and that it leads peers to pay a greater attention to their partner. For instance, the subjects often decide to join when they wish to have an intensive conversation. This can be related to studies of audio/video-conferencing in which subjects report to be more aware of their partner's attentional state (e.g. "I could readily tell when my partner was concentrating on what I was saying") when the setting includes video-conferencing rather than when it is only audio-based (Watts, Monk and Daly-Jones: 1996).
- Another interpretation is that the users' location is related with the content of their interactions. In this study, the data (MOO objects) necessary to solve the problem were distributed in different rooms. Co-presence increases the probability that subjects are concerned with the same data, i.e. talk about thing and hence acknowledge each other more frequently and more rapidly.

Peers monitor their partner location.

The previous results imply that the subjects maintain knowledge of their respective position in the virtual space. One might expect that they often verify positions by directly asking it or via MOO commands. This was however not the case in our study. This result can be explained by the design of MOO environments. Every time an agent 'pages' another one, the latter receives not only the message itself, but also a short message generated by the system which indicates who paged and from where [1]. The environment also provides information when users join or leave each other. Moreover, when peers are in the same virtual room, their actions are generally visible to each other. We have however no guarantee that the users pay attention to these messages. We hence designed a second series of experiments

3. MOOs provide different commands for communication: the 'say' command transmits the message to any user located in the same room, while the 'page' command, followed by the receiver name, transmits the message to the receiver wherever (s)he is located. etc. In this experience, we modified these commands in such a way that exactly the same number of characters were necessary to communicate in the same room or between different rooms..

1. The MOO being a programming environment, one can modify the messages automatically generated by the MOO when some commands are performed.

(Montandon, 1996) in which we compared a standard MOO (providing all automatic messages) with a modified MOO in which these messages were suppressed. The task selected required a good level of spatial monitoring: users were sent to a labyrinth if they accidentally went to the same room. Not surprisingly, the subjects in the MOO without automatic messages performed significantly more acts of spatial monitoring ($T(19,1)= 3.28$, $p< .05$). These results then become consistent with the spatial sensitivity reported in the previous section: the variation of communicative patterns in copresence requires some monitoring of mutual positions, but this monitoring is carried out at low cost (few interactions), provided by the MOO.

Space is the main criterion for division of labour

Collaborative processes often include co-operative phases, i.e. phases with a systematic divisions of labour (Dillenbourg, and al 1996) and *space was the main criterion for division of labour.* The subjects had to collect information from 12 suspects located in different rooms. All of the 20 pairs co-ordinated their work on a spatial basis (e.g. one explores the rooms in the upper corridor and the other in the lower corridor). Two pairs used also another criteria (staff versus guests, males versus females) but only for a short period of time.

Space supports (implicit) coordination

The user path reflects his or her strategy (at least if it seems to follow a direction) and one partner may anticipate the other's intentions by tracing his or her spatial path. Each partner can observe where the other goes without asking him explicitly. Moreover, partners can express (dis)agreement by performing actions or movements. For instance, sometimes, one user might suggest to the other that (s)he should ask some questions to a suspect, the second user does not answer by words, but simply moves to this suspect's room thereby acknowledging his or her partner suggestion. Or, conversely, (s)he may express disagreement by going to another room. This form of negotiation by action (a sort of speech acts in reverse) applies also to various other MOO commands, not only those relating to spatial positions.

Space supports building shared knowledge

Copresence creates a *micro-context* which supports verbal negotiation. In this study, when the users meet, they expect their partner to say something about the suspects or the objects present in that room. This micro-context helps to establish mutual understanding, namely to solve references in the use of pronouns. For instance, in one observed pair, both users were in the kitchen. Sherlock asked Oscar Salève what he did the night before. A few seconds after, Hercules said "he is lying"[1]. This "he" was grounded, because Hercule and Sherlock had both seen Oscar's answer and also because Oscar was the only suspect in that room. The context had hence been narrowed down by the spatial architecture, the scope for misunderstanding would have been broader if all suspects were in a unique room.

Mutual understanding is also improved by knowing where one's partner has been. For instance, if Hercule knows that Sherlock went to the room 5 and that Hans (a suspect) is located in room 5, then Hercule may infer that Sherlock has *probably* collected information from Hans. This is dues to the fact there was an almost one-to-one reationship between knowledge sources (suspects and objects to be looked at) and rooms. The virtual space helps to *know what one's partner knows*, a first in building a shared understanding of the task (Clark & Brennan, 1991; Dillenbourg & Traum, 1997)

Synthesis of the first study

This study shows that virtual space does actually influence MOO users behaviour beyond strictly functional criteria (i.e. beyond the fact that some commands vary according to space). Because of the close *relationship between the virtual space and the problem space*, the users may interpret mutual positions, movements and actions in virtual space in order to build mutual knowledge regarding the problem state, the problem strategy or simply what the other means.

These results concern a particular collaborative problem solving task. However, the current evolution of dialogue studies shows that other categories of dialogues, often considered as one-sided, are intrinsically collaborative: Explanation (Baker, 1992), tutoring (Douglas, 1991) and technical assistance (Moore, 1995) depends on the joint effort of participants to reach mutual understanding. Participants collaboratively elaborate a shared context which give sense to utterances. In virtual spaces, rooms and objects, visible by both users, support the collaborative construction of interactional context.

1. We translate from French.

Second study: The STAF experience

The post-graduate Staf diploma at TECFA is dedicated to «Educational Technologies and Learning Sciences». It is composed of 14 modules distributed over two years[1] and is based on a mixed presence and distance teaching scenario. The first academic year is divided into six periods of five weeks (three per semesters). Each period starts with a full week of work in presence followed by four weeks of learning and teaching activities monitored at distance with Internet tools. To support these activities, we are progressively involved in the design of a «virtual campus» (Staf VC).This scenario allows students to study at their own rate from their home and/or workplaces. Its main advantages are not only to solve time and space constraints, we also wanted to integrate the spatial metaphor as an organisational and communication medium to improve students' learning strategies.

The four years of experience accumulatively leads us to a certain number of reflections on the status of space in virtual teaching. We started with the problem of information organisation within the Staf VC. We noticed that when a student wants to find information, it is easier for him to ask the relevant person than to browse a database. Information is organised in the real world by people who managed this information for their own needs and not for other users. We tried to implement this way of managing pedagogical resources in relation to the problem of synchronous communication and support to tutoring processes.

Information Organisation Resources in Staf VC

There are several ways to find information in the STAF Virtual Campus. Like in any information system, students can browse through the TECFA WWW server using Altavista like search engines. In this case, the main advantage is that search is exhaustive but this method is really effective when you know that a particular document is on the server and not the location. Otherwise, the information gathered is generally difficult to interpret because it is given without the contextual knowledge in which it was produced. The metaphor that supports this kind of information system is the classical arborescence of folders and files.

An another method is to browse throughout the server using different virtual organisational entities(the hyperdocument metaphor): courses, trainers or students. From

1. For more details on curriculum see http://tecfa.unige.ch/tecfa/teaching/post-grad-general/diplome.htm

the courses' pages, students can find the courses contents (slides, bibliographical sources, exercises and examples of solved exercises). The documents are contextualised by the semantic domain of the teaching materials. For instance, specific comments on bibliographical references make sense within a course as they are chosen to extend a lecture. From the trainers' pages, students can find additional information about teachers' research topics and relevant scientific papers as well as links to the teachers' courses. Contextualisation is produced here by the scientific interests of the researcher. From the students' pages, they can find other work examples (whether in their own class or in previous classes) and, of course, teachers can view and evaluate the students' work as each of them has a reserved area on the server. This method is well suited for stabilised information such as pedagogical resources, scientific papers, project descriptions.

Synchronous communications in STAF VC

It happens that students or trainers need to search for new information that is not at their disposition in the hyperdocument WWW server. They may also need personal help or comments on a specific problem. In this case, the most efficient way is to ask directly the relevant person for help. Therefore the VC should also provide means to contact in an asynchronous or synchronous way any member of the academic or administrative staff. Electronic mail is an efficient way to solve this kind of asynchronous interactions but it is also possible to go farther using text-based virtual realities like MOO environments.

When synchronous communications are required in STAF Virtual Campus, it is easy to connect on the TECFAMOO to contact the right person. For most students, a direct connection to their MOO virtual office is also available from their WWW home page. We have already seen that one interesting aspect of MOOs is that they impose a spatial metaphor to the participants. Thus, one may talk and interact easily with people (teacher or student) in the same virtual room, and may use other means to communicate with people in other locations. Moving from one room to the other is also a very simple task on the MOO as participants just have to enter an exit name. Moreover, join and invitation facilities can be used to move between unconnected places.

MOO can be an effective way to hold pre-arranged meetings for students who can't be in the same physical location. It can then become the ideal means of communication for distributed learning communities which main property is not to be able to have face-to-face courses or informal meetings without lots of students travelling. Transcripts of the meetings can be saved and emailed to people who weren't present. Using a MOO in this way is not as time-effective as meeting in reality (if we do not consider journey time), but is less expensive and at least as useful as having a conference telephone call. In many cases these features compensate for relative slowness of “typed” discussion. However, Moo communication is not just “typed text”. Text entered is revisable and backtraceable, two features that have distinctive advantages over direct voice communication.

Space supports analogical reasoning

For four years now, teachers’ and students’ experience shows that such a knowledge structure is really affordable in terms of investments and ease of use. As the space allows knowledge to be very incremental and modular, the investment from the teaching staff is largely reasonable. Moreover, as everyone shares the same capabilities to understand space relationships, the use of the server is extremely easy.

Indeed, spatial concepts make use of our capabilities to understand quite complex relationships between objects and ideas. MOO systems, for instance, describe a very rich space based on the campus metaphor. Spatial representations are used frequently to convey one or more attributes of the information objects to the user: sorting, grouping and so forth. When users move, use or create objects in space they communicate some relationship either to the system, or to some other user or to themselves. The primary advantage of space is that there is more "room" to put objects in and that not the whole space is always "in front of the user". Objects can be moved closer or farther away and the metaphors of the room, the house or the city provide container metaphors for objects that are easy to understand. This type of space is therefore useful to organise large collections of objects. *The main advantage of spatial user interfaces based on the real life metaphor is in the ability to communicate a spatial relationship easily to other users.* Indeed people are used to navigate in real life spatial environments based on very vague descriptions and facts. They are also generally used to memorise relationships of objects in spatial terms. People might communicate about the location of documents even more naturally when the MOO server is coupled with a WWW interface and hypertext links. Thus spatial concepts are a natural way to organise information and communication about spatial properties which are typical tasks for humans. Spatial metaphors is thus not only relevant for human communication (you join somebody to have a talk or you organise a meeting in a specific room) but also for object organisation and in our concerns, objects can be records of previous meetings, black boards, information notes, posters, slides and so on.

Conclusions: Take space seriously

Virtual campuses, and -more broadly - all Internet-based education/training tools are generally justified by the fact that the audience cannot attend to classical lectures because of distance or time constraints. Distance education and in-service training are therefore natural 'niches' for virtual campuses. Within these 'niches', the fact that a teacher distributes CD-Rom with recorded lectures or puts her lectures notes on WWW is justified by 'accessibility' arguments, despite the fact that such practices reproduce the most criticised aspect of university teaching methods. We want to emphasise here that the *pedagogical quality of virtual campuses is more seriously discussed when it applies to cases where 'accessibility is not a sufficient argument*, for instance in standard university courses or to STAF-like approaches, mixing presential and distance teaching. Virtual campuses for standard (undergraduate) university teaching is the real challenge for the coming years.

In these cases, the issue is not anymore to do at a distance what you would do in presence, but *to use the Internet wave as an opportunity to renovate universities*. The direction we suggest, at a first glance, is fairly simple: teachers design learning activities and the virtual campus provides the resources that students need to accomplish these learning tasks. Why would a virtual campus be more efficient than traditional practices to support these resources and tasks? The answers concerns the availability and organisation of resources.

- Availability. Some resources are only available on Internet (e.g. on-line measurements in climatology), in other cases, the Web provides the critical mass: Consider a class of 150 students who develop 50 independent group projects, the scope of resources to be provided goes beyond what the teacher can document, (s)he needs to rely on what is available in the world or to collaborate with other teachers. It is interesting to observe that the Web supports collaboration between teachers, because teachers can jointly construct useful resources without having to subscribe entirely to each other's methods.
- Organisation. The more resources are provided, the more important it is to structure them in such a way that the students do not waste their time looking for useful resources. The spatial metaphor is a tool for organisation. It should however be emphasised that the mere definition of spaces (buildings, rooms, ...) does not guarantee an efficient access to resources. There are bad and good architectures and to discriminate them is on our research agenda.
- Interaction. As shown in the first study, the spatial metaphor supports the way users interact about the information they find in the virtual space. Once again, it would not be sufficient to say that 'space is good'. The results show that particu-

lar space features support interaction in different ways: co-presence promote shared conversation context, mutual 'tracing' supports mutual modelling of knowledge and implicit co-ordination of problem solving strategy.

In this context, space has to be treated seriously: it is not simply the decor of learning activities, it has indeed to be purposely designed to support productive learning interactions.

Acknowledgments

The first study was funded by the Swiss Natioonal Science Foundation under contract 11.40711-94. Thanks to David Traum and Lydia Montandon who contributed to the study of space in virtual realities.

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