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# CLIMATE: A framework for developing holistic requirements analysis in Virtual Environments

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**Abstract**

Personal ([2] C. Barnatt, *Cyber Business — Mindsets for a Wired Age*, Wiley, New York, 1995) computers and networks have transformed communications in the workplace over the last decade. Tomorrow's society is likely to revolve around the use of Computer Mediated Communication (CMCs) to eschew the geographical distance between individuals ([27] N. Negroponte, *Being Digital*, Hodder and Stoughton, 1995; [28] D. Norfolk, *The virtual enterprise, Information Age* November Issue (1995) 32–39). A new dilemma for designers of this technology will be discovering ways of humanising systems development and design. This paper develops a framework called CLIMATE *(*Community, Language, Interaction, and Medium in the Analysis of Telepresence Environments*)* which may ultimately be used for capturing user and environment requirements. The virtual environment that forms as a result of this CMC is rich in social nuances, such as on-line friendships, communities and so on, that sometimes reflect the elaborate cultures of real life ([37] H. Rheingold, *The Virtual Community*, Minerva, 1995). CLIMATE is intended to help in capturing a more holistic picture of requirements, in terms of the users, task, and environment. The approach is inductivist, relying on gathering rich data from log transcripts, participant observation and questionnaire surveys. It is intended that CLIMATE will provide a step further towards integrating social and technical design requirements in the application of CMCs. 

*Keywords:* Computer-mediated communications; Virtual environment; System design; Requirements analysis

## 1. Introduction

Collaborative computer mediated communication (CMC) is a generic term for the communication process undertaken through physical tools such as the computer, local and wide area networks and associated software. Perhaps the best working example of CMCs being used to further business interests is provided by Bill Gates

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| **Systems Analysis and Design Approach** | **Structured Systems Analysis and Design** | **Human Activity Design** | **Participative Design** | **Holistic Design** |
|---|---|---|---|---|
| ***Example*** | SSADM V4 | Soft Systems<br>HUFIT | ETHICS<br>MULTIVIEW<br>COMPACT | CLIMATE? |
| ***Emphasis*** | Functional Requirements Work Process | Human requirements in functional design | Consensus in participative design | Environmental design |

Fig. 1. An evolution of Systems Analysis and Design methods.

of Microsoft Corporation. Gates's philosophy, as his various advertising campaigns illustrate, is that regardless of geographical distance, collaborative technologies result in the 'Global Village' concept. The primary belief is that CMC technologies encourage telepresence environments also known as Virtual Environments (VEs); an artificially generated sense of physical presence and environment created through the use of the computer interface and the social contributions of the users. CMCs also make it possible for organisations to gain a synergy of strategic knowledge; in so much as every user's knowledge contribution enhances the environment and results in the creation of new knowledge. The technology to make such benefits viable is available, examples of this include Internet Relay Chat (IRC), groupware; and shared textual environments used to play adventure games in the style of 'dungeons and dragons' known as Multi User Dungeons (MUDs). However, a requirements, analysis and design process that suits the nature of telepresence environments still does not exist. VEs must be designed and implemented with the benefit of the end users in mind. This necessitates designing VEs with an understanding of the social and psychological requirements of the users. This may be best achieved through understanding the users' interaction with the environment and other users, and the nature of the task in which they are involved.

## 2. The virtual environment

The VE may be described as a collaborative social environment that employs computer mediation, namely CMCs. The participants are likely to be geographically dispersed; therefore contact is through telepresence. Participants form a 'Community of Practice' (COP) [20] through a process of distributed cognition [16], shared meaning and syntax, situated learning [4] and group dynamics such as role taking.

User centred issues are of paramount importance in the development and design of

virtual environments. This is because the end users are ultimately the biggest stakeholders driving the success or failure of the technology [13]; if they do not like the technology, they simply will not use it. This 'acid test' of usability must be the ultimate test of technology success. VEs offer the opportunity for end-users to develop collaborative environments rich with social nuances, thus providing the benefit of encouraging users to be more active in collaboratively shaping their own social culture and dynamics on-line. Traditionally, problems for end-users include a lack of user involvement, which results in a failure of the system designer to gain knowledge from the users or for the users to become more knowledgeable, and inadequate users-designer communications, which results in divergent goals in the design process [19,21].

These issues were addressed to some extent by socio-technical approaches to systems analysis and design, such as ETHICS [26], Multiview [1], and to a lesser degree by Checkland's soft systems methods [32]. All these above methods have covered the issue of the human operator in the system structure; however, they are not suited to VEs because they do not address group and collaborative computer supported work, and the ensuing changes involved in the work practice and process when using CMCs. Instead, they are methods that essentially address the well being of the individual participant within the larger context of the system. The research objective of the authors was to develop a holistic approach to SADM. The CLIMATE model is intended to be a potential next stage in the evolution of systems analysis and design methods. Fig. 1 demonstrates the evolution of Systems Analysis and Design Methods (SADM), and the potential niche for the CLIMATE framework.

CLIMATE is an acronym for Community, Language, Interaction and Medium in the Analysis of Telepresence Environments. These four dimensions (community, language, interaction and medium) are the result of an extensive literature review in the area of collaborative CMCs, Computer Supported Co-operative Work (CSCW) [6] and related topics. It is intended that the CLIMATE approach captures a more holistic perspective of the technical environment to be designed by incorporating social aspects such as group interaction and the building of COPs. CLIMATE would be applied more particularly to the design of VEs, as the socialisation process in VEs results in the generation and synergy of new knowledge. It is hoped that resulting research conducted by the authors can also be used to capture some measure of the influence of CLIMATE dimensions in the development of VEs in different CMC technologies.

The CLIMATE dimensions represent a set of factors seen repeatedly in the literature in various forms that clearly has some impact on user and design issues, but to date has not been incorporated in any great detail into a systems analysis and design approach. The definitions for these four dimensions are as follows:

*Community* (of Practice): This refers to a group of people who appear to share a common cultural interest that develops through the process of learning from each other's knowledge and the knowledge they generate amongst themselves over time. The literature review demonstrated that:

- As a result of social interaction and the development of shared understanding users play an active part in the design of their environment [25].
- Multiple channels establish a sense of 'common ground' [22,34,35].

- People undertake a series of social steps to get to grips with their artificially generated environment, e.g. establishing roles [8,9,10].
- People develop a 'Community of Practice' where they can situate their learning [20,39,43].

*Language:* The use of shared meaning and syntax in the development of a VE. Shared meaning, vocabulary and interpretation may be in text form or more abstracted form such as the use of symbols. The literature also demonstrated that:

- As well as shared knowledge, people share syntax, vocabulary, interpretation, ontology and semantics through collaboration [12].
- Through the process of community, symbols come to have a categorical relevance to aspects of culture, ritual, myths, and stories [24].
- Categories of objects coded in the language reinforce community interaction [3,29].
- Conventions of behaviour are developed through the use of language and symbols (e.g. emoticons) as semiotic tools [7,31,38].

*Interaction*: The process of interaction between users through distributed cognition and artefact sharing, in undertaking the task of developing a VE. Interaction using these processes of distributed cognition and artefact sharing involves the development of an externalised (as opposed to internalised) mental framework that is shared between the users of the same system. This framework is cemented through its application to an artefact(s) which becomes a representational reminder or cue to the users of the system. The literature also demonstrated that the interaction can be between people or artefacts in the environment:

Interaction between people [15].

- Allows the joint construction and distribution of experience and insights.
- Enables social construction of stories and narration shared by the members.
- Supports feedback and review mechanisms among members of the user groups.

Interaction between people and artefacts [17,18,30,33,36,41,42].

- Technology allows participants to use many modes of representations (e.g. simulations) to construct new understanding that leads to conceptual change.
- Representation forms the basis for understanding tasks that involves a sharing of significant knowledge (distributed cognition).
- Artefacts when validated through any group participation or design becomes distributed between people.

*Medium*: This is the hardware, software, and various interfaces that users employ to establish and maintain contact with other users, and that may effect and affect the development of a VE. The literature review indicated the following related aspects:

- The interface of the collaborative technology, i.e. the various front-end software systems being used provide powerful tools towards solution making in groups (e.g. computer based modelling, on line referencing, and so on) [5,14].
- Levels of Interactivity, i.e. asynchronous versus synchronous or real time communication

✠= *denotes the importance of that dimension in the development of a VE*

✠/▭ = *denotes that the differing quality of that dimension (either + or -) affects the final quality of the VE.*

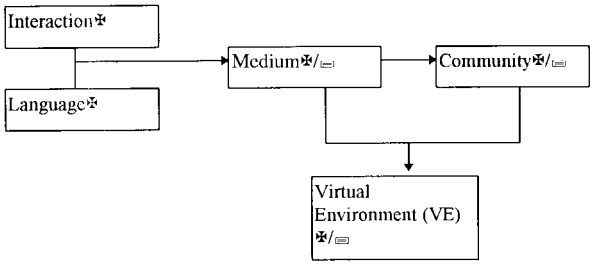


Fig. 2. A model of the CLIMATE dimensions in relation to VE design.

– rates of transmission and quality for example, affect the quality of communication in the VE, with real time communication being the most appropriate for such collaborative technology [23].

- Permissions and data status, the read and write capabilities of the system as well as private versus public data permissions for the users affects interaction levels [23].
- The granularity of the communications, such as the effects of time lags on the communication or in 'turn taking' can make comprehension limited or difficult [23].
- A hypothetical model demonstrating the inter-relationships between the four CLIMATE dimensions is shown in Fig. 2. This model also illustrates the relationship of the dimensions in relation to the successful design of VEs.

## 3. In search of CLIMATE

In order to test the hypothesis put forward in the model, the following CMCs are being investigated:

- Various text based MUDs. MUDs are virtual environments that employ text as their means of communication. Multiple users can communicate in relative real time and through a process of 'suspension of disbelief' involve themselves in interactive adventure gaming. The three dimensional world is created through rich and descriptive language.
- Text and graphic based MUD known as MOO (Multi user Object Oriented) prototype. A MOO allows users to manipulate objects, as well as to represent themselves in graphical form. The graphical form is known as an avatar.

The use of video conferencing has also been considered. The analysis of the MUD,

MOO, and video conferencing was to resemble an evolution from simple based text communication (MUD), through to a system that closely resembled face to face communication (video conferencing). We discounted video conferencing as it has to date had very limited desk-top use, and in desk-top terms is still a reasonably new and emergent technology subject to many technical and interface problems. We chose MUDs because of their relatively wide availability, whereas the MOO was selected primarily because it was a prototype being run by one of the author's sponsors.

Before embarking on the study we also compiled a list of indicators that would be investigated in order to demonstrate the presence of the CLIMATE dimensions. These included:

### *3.1. Community*

- Develops through the questioning process that 'newbies' (new users) employ to take stock of the artificially generated environment. They do this by learning the accepted practices of the community from more experienced users.
- In the MOO environments, the avatars allow the users the extra facility of being able to express themselves with more than just text but with some limited body language too, such as smiling, waving, frowning and so on. This more closely resembles the face to face communication that happens in real life. It also makes it possible to create more physically based communities built around artificially generated 'corner shops', 'town halls' and other places of common interest designed or chosen by the users themselves.
- MUD and MOO participants rely on more established members for guidance on the practices of that community.

### *3.2. Language*

- Users use 'emoticons' as a means for expressing emotions that cannot be expressed through the limitations of text, e.g. equals a smile. They also employ capitalisation to attract other users' attention.
- Users develop specific language in keeping with the theme of their MUD, for example, in the MUD island the typical greeting is "Hwii".
- Presentation of written language is of relatively little importance to the users, but rather the meaning that is conveyed through the language; as such, transpositions, misspellings, and omissions are regular occurrences.
- The richness of language used, e.g. metaphor, symbolism and so forth comes to have categorical reference to aspects of the culture, myths and stories of that community. In other words, they become entrenched in their environment through the use of rich language that allows them to create their own shared metaphorical world.
- Users can make reference in their language to specific virtual locations which come to have categorical reference to aspects of the culture, myths and stories of that community and which may have special significance, e.g. a virtual town hall displayed graphically (visual language), described textually or metaphorically.

### 3.3. Interaction

- In MUDs the process of distributed cognition is not similar to the distributed cognition process described by Hutchins [16]. Hutchins explained the process of distributed cognition through an example of airline cockpits. He cites the example of the "Vref" used to indicate the velocity, pitch and angle of wing slats according to the weight of the plane for landing purposes. Hutchins also discusses the various artefacts used by the pilots in the process of landing the 'plane. These are the various gauges for velocity and height, and pre-printed plastic cards which provide the pilots with references to weight and speed, and adjustments to be made accordingly. He describes how both the pilot flying and the co-pilot not flying share the same distributed cognition through these artefacts, their own individual task specifics, and a series of verbal callouts that act as a checking and insurance mechanism that both pilots are sharing the same representation for landing the 'plane. The key difference in distributed cognition of MUD environments is that Hutchins' distributed cognition model is dependent on a previously highly trained group of individuals who have shared the same type of training. Although the pilots are not necessarily trained together or from the same airline, they will be trained on the same aircraft type and share a typically generic form of procedural training and modus operandi. Therefore, they should find it relatively easy to adapt to the same distributed cognitive process of landing the craft even though cockpit protocols may differ slightly. In MUDs the process of distributed cognition evolves through a process of social interaction between users from various backgrounds and levels of training who through group debate, brain storming, and knowledge exchange come to a decision on their own representational artefacts and what the artefacts come to signify jointly in their cognitive processing.
- There is more opportunity to develop distributed cognition in a MOO because of its object oriented graphical nature. Artefacts can take on more tangible forms for the users (through the graphical representation), e.g. the representation of a meeting place such as a town hall. As the representation is developed using object orientation it can be manipulated and customised by the users (changes in colour, style, shape and so on) to suit their requirements.

### 3.4. Medium

- The specifications of the user's computer limits their level of interaction with others, because of rates of transmission and synchronisation, etc.
- The quality of the communication (granularity), such as time lags because of different user machine specification can affect comprehension and make turn taking difficult.
- MOOs use more sophisticated technology; therefore, there is more of a need for users' machine specifications to be standard, e.g. minimum Pentium with sound card. This resolves some issues of granularity and transmission problems.
- The interface of MOOs arguably tends to facilitate ease of operation as it is window based to allow users to view their three-dimensional graphical environment at the same time as communicating with other users.

- A better interface improves users' ability to share their knowledge and develop solution making groups, i.e. access to other compatible software to allow on-line referencing.
- Synchronisation between the users' avatar actions, and 'speech' are delayed which causes confusion, misconceptions and can make comprehension difficult or limited.

The aim of this study is to establish the existence of the CLIMATE dimensions using alternative research methods that may produce a richer picture of design and user issues in CMCs. Eventually, it is envisaged that the results of all the case studies will produce a set of requirements methods for design and analysis capture of CMCs. The approach taken in this research is inductivist [44] and is based on the discovery of categories of coding in the data in relation to the literature review; a degree of coding is also in vivo. Grounded theory was used to build assertions from the data. This theory, developed by Glaser and Strauss [11,40], was designed to develop and integrate hypotheses and concepts (deductive process) into an integrated theory (through inductive process). For this reason it is most suited to the requirements of this research.

## 4. A MUD study to determine CLIMATE dimensions

### *4.1. Design*

In this specific case study, the investigation centred around the use of a text based collaborative technology known as 'ICQ', in essence a MUD that allows participants to experience telepresence through a number of tools. This CMC is designed to let users exchange text and chat, web references, and file transfers. The users were asked to conduct a group task during a specific time period.

### *4.2. Participants*

Five participants (four males and one female in the age range 22–35 years) took part in the study. Participants were all PC users of six years experience or more. Their experience of ICQ was mixed between users who had never used the technology, to those who had two to three test sessions with ICQ. Two of the male participants participated through the use of the Wide Area Network, as they were geographically distanced from the site. The other three users were located on-site but physically apart and using the Local Area Network for access.

### *4.3. Materials*

ICQ software was set up on the local area network and a questionnaire devised. The questionnaire requested the users to provide a rating on CMCs generally, as well as some feedback on the collaborative technology that was being used.

### *4.4. Procedure*

1. The users were expected to create an advertising campaign for a television series. Each participant was provided with one piece of data or information in a different

Table 1
User comments and preferences from the questionnaire[a]

| User Preferences and Facts | Number of participants (out of five) |
|---|---|
| Face to face group discussion preferred | 5 |
| Email used often | 5 |
| Text and graphic in task management preferred | 4 |
| Rates and quality of information transmission important | 4 |
| Face to face communication preferred over all other communication | 4 |
| Face to face problem solving preferred | 4 |
| Computer usage over 6–10 years | 4 |
| Social communication relatively easy in CMCs | 4 |
| On-line communities more fleeting than traditional communities | 4 |
| Need for support and review feedback mechanisms in CMCs | 4 |
| Ease of use of the technology important | 4 |
| Sharing of vocabulary, syntax, etc. important in CMCs | 4 |
| General communication preferred in text | 4 |
| Combinations of media preferred in interface | 4 |
| Simplicity of system is important | 4 |
| Information shared by the users become part of the community (categories of information) | 4 |
| Crisis handling better performed face to face than with technology | 3 |
| Use of chat areas in work | 3 |
| Common ground established between users through different channels of communication | 3 |
| Use of technology for communication | 3 |
| Learning task through technology multi media rated highly | 3 |
| Hypertext preferred as information passing mode | 3 |
| Project work preferred face to face | 3 |
| Efficiency of information transmission important | 3 |
| New work task easier to learn face to face | 3 |
| Collaborative technology aids communication between geographically dispersed groups | 3 |
| On-line communities important | 3 |
| Development of on line shared understanding important | 3 |

[a] Note: viewpoints that showed an agreement rate of less than three participants are not depicted in these tables. The data will not be discarded, but serve as a source of reference in later research when more statistics can be assimilated.

multi-media format, e.g. one participant received a sound file, another received a URL (Universal Resource Locator) for the web, another a text file and so on. The above files were all related to a television series as shown in Appendix A, but needed to be assimilated by the group into a useful advertising campaign, i.e. a web page. It was up to the participants to form a task force to make this possible.

2. The group then had to come up with two new words that described this series, and to create a definition for them, that could be incorporated into the advertising statement.
3. The group then had to decide amongst themselves who would present the finished product, and send it to the authors (role playing as the Managing Director) for inspection.

Table 2
User preferences in relation to ICQ

| User Preferences and Facts | Number of participants (out of five) |
|---|---|
| ICQ systems ability to co-ordinate group activity was bad | 4 |
| Adequacy of real time good | 4 |
| Good levels of community formed | 3 |
| Ease of use | 3 |
| Failure rate high | 3 |
| Immersive capacity good | 3 |
| Quality of data received and transmitted good | 3 |
| Level of user 'friendliness., low | 3 |

The following data was collected:

1. Participant observation of the chat window in ICQ, which was recorded for further qualitative analysis in the form of a log.
2. A follow up questionnaire administered after the case study.
3. An error and comments sheet provided for the participants for use during the case study, i.e. subjective data capture.

The data set was not large enough to allow conventional statistical analyses, because of the small number of participants. However, some general points could be made. These are presented in the Tables 1 and 2.

The implications of these findings are not immediately clear; their relevance should become more apparent as the data sets increase from the other case studies. The most significant finding suggested by the data was a lack of universal agreement on the ease of use of the systems, and other related aspects such as the failure rate. It is therefore likely that there are issues relating to the usability of the system that were not captured through the questionnaire. Therefore, for the time being, the application of the findings is limited to providing some preliminary proof to findings in the conversation log analysis.

A qualitative analysis software package (ATLAS-TI), that enables coding, sorting, memoing and production of network diagrams illustrating interrelationship between codes, was used. A set of codes was generated through in vivo analysis of the logs and through the previous literature review. The logs were then examined again for examples illustrating the coding. The Figs. 3 and 4 show examples of a consecutive network view of Interaction and its related sub-dimensions.

This process was repeated to find indicators of all four of the CLIMATE dimensions until all the possible network views were produced along with relevant excerpts of the log transcript illustrating examples of coding.

## 5. Analysis of the transcripts

A number of early but interesting findings was established. These findings will eventually contribute to the grounding of a theory on the nature of VEs in different types of collaborative CMCs.

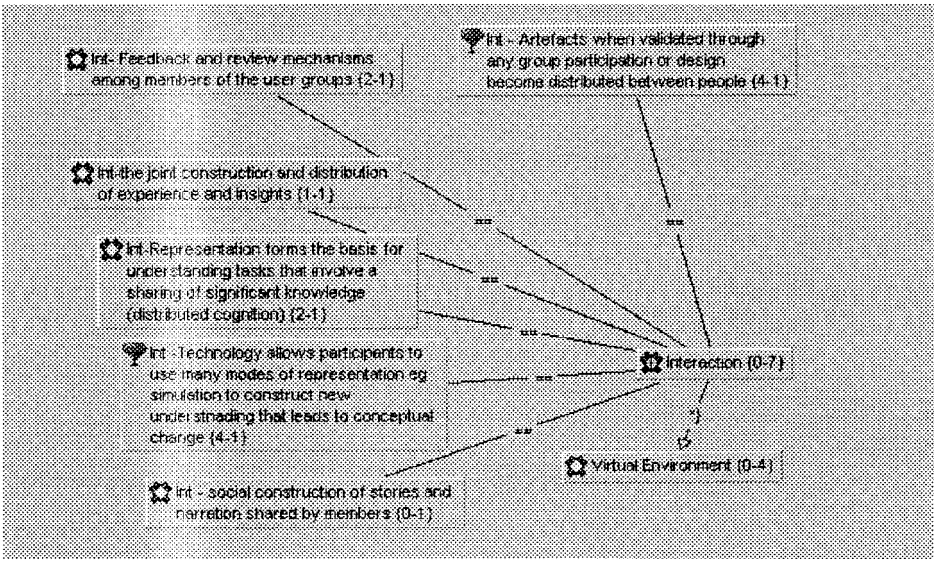


Fig. 3. A network view of the dimension ‘Interaction. and its associated codes. Note: the legend = = denotes an ‘Association’, the parenthesized numbers illustrate a count of the number of transcript segments that correspond to that dimension.

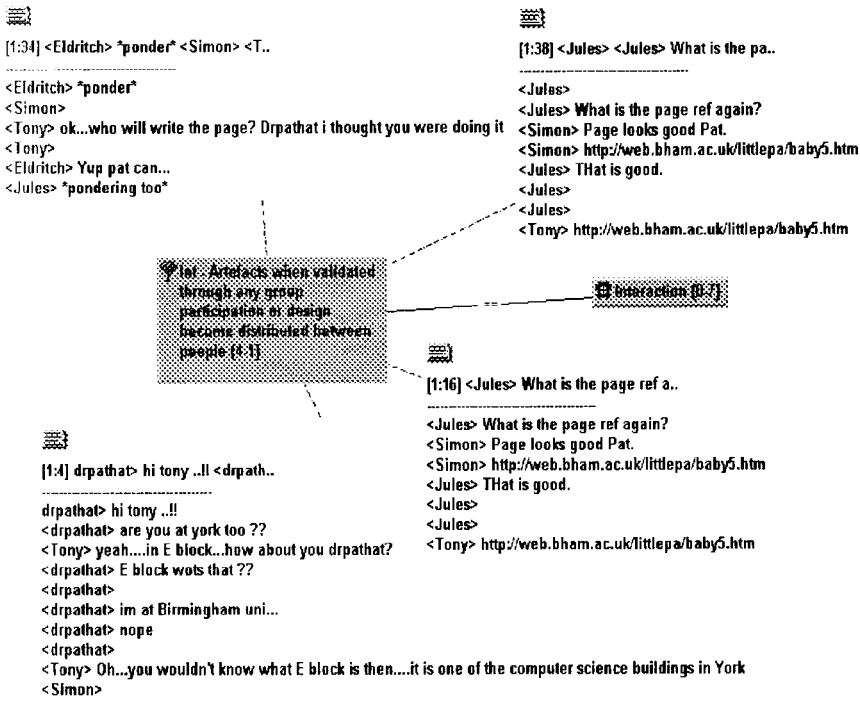


Fig. 4. A network view of transcripts that support the code “Artifacts when generated… ”.

In the Interaction dimension, participants demonstrated an active role in developing artefacts through participative design, e.g. a web page to illustrate their joint task. In this particular study, the artefact came to have a distributed and shared meaning to the users. This finding correlated with our supposition that the process of distributed cognition in MUDs differs from that distributed cognition process described by Hutchins [16].

In the Community dimension, participants employed questioning techniques to ascertain their roles with each other and the expectations required of them. This closely correlated with our supposition that new users employ questioning to take stock of their artificially generated environment. Participants also used a high degree of informal social interaction, including greetings, to familiarise themselves with their environment and other users.

On at least one level, a provisional link between the dimensions of Community and Interaction could be ascertained. It appears that a common artefact must come to have a socially accepted and agreed relevance in order for a COP to form. In this study, this link revolved around the web page as an artefact.

In the Language dimension, participants employed numerous language methods to express themselves; these included the use of emoticons to describe their emotional state, and the use of capitalisation to emphasise their personal viewpoints. This fits closely with our earlier supposition that users find means such as emoticons to overcome the limitations of the medium, in this case, text.

In the dimension of Medium, it was noted that communication was severely affected by time lags, resulting in incoherent conversation flow and some disruption. This disrupting force was traced back to the fact that every participant had different computer specifications and was therefore unable to receive standardised communications.

A provisional link between the dimensions of Language and Medium can be supposed. Users may take short cuts with their language in order to convey as much as possible in as few words as necessary. They may be doing this in order to compensate for a Medium that is not one hundred percent reliable.

A key finding was that the participants actively attempted to make their environment as ‘friendly’ as possible. They made every effort to form social ties, alliances, and to create a sense of community with each other. This was despite the restrictions of time placed upon them to complete their task. In fact, over three quarters of the transcript was given over to social communication, with the remaining quarter only allocated to task work.

The overall findings of the follow up questionnaire discovered that participants feel that face to face communication is most effective in completing any group or task activity. Also, CMCs are limited by the technology and a lack of social conventions. Hence, the user must compensate for these limitations to achieve success.

We would assert that the case study highlighted the significant lack of unity in design and use issues relating to CMCs. This is probably a result of the rapid evolution of CMCs from already existent hardware and software, and the latent problems that arise from ‘boot strapping’ sound communication concepts with technology that is forced into CMC usability and compatibility. Further case studies must be completed, along with a triangulation of the quantitative data to find evidence of emerging patterns of behaviour in relation to CLIMATE, the user task, and the collaborative technology that is being employed.

## 6. Discussion

The case study was not without its problems; some of which could be considered as limiting factors to the findings. First, the small number of participants resulted in a narrow spectrum of results. Therefore, statistical evidence was poor. Second, participants' unfamiliarity with ICQ resulted in a steep learning curve, the effect of which was that participants had only just enough time to complete their task. Finally, technical problems with ICQ primarily because of the fact that each participant's PC had different hardware specifications resulted in many system hangs during the session. It may also be reasoned that a more rigorously controlled experimental approach would have suited this study better. However, we would argue that the rich source of data for qualitative analysis could not be obtained through less flexible and more controlled means. The participants needed to feel that the observation was unobtrusive in order to relax more fully. In a more relaxed state, the participants were more likely to exhibit their natural behaviour, thus providing us with the opportunity to draw more holistic conclusions from the study.

The specific relevance of this research study is the different approach that it takes to systems analysis. The CLIMATE approach is intended to be more holistic and flexible in nature, compared with the rigid, structured approach of most systems analysis and design methods. A holistic approach is particularly suited to the design of VEs, because the socialisation process in VEs results in the generation and synergy of new knowledge. It is not static like the traditional 'input-process-output' of other technologies.

The preliminary results from this study show a source of rich empirical data that may eventually be used to aid the design of virtual environments, according to the characteristics of the users involved, the task, and the environment. The questionnaire findings, although not large enough to draw statistically valid generalisations, demonstrated some interesting and important issues for system designers concerning the viewpoints of the end user. The findings imply that users:

- are looking for environments that closely fit the social environment of real life;
- seek community, even in artificially generated environments;
- believe that social issues relating to culture formation, such as language, shared history, and context are important to them;
- want environments that combine technical quality with social values.

The message is that we must consider new methods that allow for more detailed analysis of social aspects affecting the users and their environment. The value of the results of this study is that in due time they will offer greater insight into the users' preferences; and design for virtual environments that reflect the users' requirements. On an organisational level, it may be possible to fit user characteristics to specific tasks in specific computer mediated collaborative environments. This will result in greater efficiency in use of labour. Ultimately, though, the benefits will be to the most important and currently most neglected link in the chain – the end users.

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## Appendix A

"Babylon 5"© returns to Channel 4 this Wednesday. It is a long running science fiction series that appeals to a section of the population. It is your task to come up with a new advertising campaign that can be used to capture more mainstream audiences. Each member of your task force was assigned some form of information resource that would prove useful in your campaign if shared and assimilated between the members of your task force. Remember that you are geographically dispersed and therefore it is up to you to co-ordinate the required task amongst yourselves. You are required to complete the following.

1. Using the ICQ software available to you and any necessary window based software, such as a Word Processing package. Create a HTML document that could serve as a Web page for this advertising campaign. Incorporate as many multi media aspects as you can into this page. The design, style, location and content of this web page is up to the task force.
2. Invent 2 new fictitious words (and provide definitions for them separately if possible) and incorporate them into your advertising text in the HTML document.
3. Allocate a team leader who will be responsible for transmitting the completed task to the Managing Director of channel 4, the Managing Director (MD) can be contacted by email i.e. tina@minster.york.ac.uk, or by using the "Queen Teen" name in ICQ.

**Please note that before the commencement of this task, all task members will be expected to have opened a chat link between all the members and the MD that must remain open and be used during this session. Please set your chat windows to record the transcripts of events. You will be shown how to do this if you do not know how this is performed. The MD will monitor the chat window.**

In the event of problems the MD can answer a limited set of questions at her discretion, she may be contacted as in (3), though she expects that her task force will be able to manage wherever possible. An Error Counter and Comments sheet has been provided for your use during the task.

*You have one hour and a half to complete this task.*

## References

[1] D.E. Avison, A.T. Wood-Harper, Multiview – An Exploration In Information Systems Development, Blackwell Scientific Publications, Oxford, 1990.
[2] C. Barnatt, Cyber Business – Mindsets for a Wired Age, Wiley, New York, 1995.
[3] H. Blumer, Symbolic interaction, in: J.P. Spradely, (Ed.), Culture and Cognition: Rules, Maps, and Plans, Chandler Publishing Company, 1972.
[4] J.S. Brown, A. Collins, P. Duguid, Situated cognition and the culture of learning, Educational Researcher 18 (1989) 32–42.

[5] H.H. Clark, S.E. Brennan, Grounding in communication', in: L.B. Resnick, J.M. Levine, S.D. Teasley, (Eds.). Perspectives on Socially Shared Cognition, American Psychological Association Books, 1991, pp. 127–149.
[6] T.M. Conkar, Exploring the use of socially defined symbols in CSCW, Unpublished Report, Department of Computer Science, University of York, 1996.
[7] M. Friere, A Socio-cultural/Semiotic Interpretation of Inter-communication Mediated by Computers', The Ontario Institute for Studies in Education, 1996, http:// www.glas.apc.org/ ~ vega/vygodsky/Friere.html.
[8] R. Gagne, The Conditions of Learning, Runthart and Winston, 1985.
[9] R. Gagne, Instructional Technology Foundation, Lawrence Erlbaum, London, 1987.
[10] G. Gay, M. Lentini, Use of communications resources in a networked collaborative design environment, Online Journal of Computer Mediated Communication 1 (7) (1995).
[11] B. Glaser, A. Strauss, The Discovery of Grounded Theory, Aldine, Chicago, IL, 1967.
[12] T. Gruber, 1990. The role of standard knowledge representations for sharing knowledge based technology, http://KSI-web.stanford.edu/KSL_Abstracts/KSL-90-53.html, 1990.
[13] T. Gunton, End User Focus, Prentice-Hall, Englewood Cliffs, NJ, 1988.
[14] M. Guzdial, J. Kolodner, C. Hmelo, H. Narayanan, D. Carlson, N. Rappin, R. Hubscher, J. Turns, W. Newstetter, Computer support for learning through complex problem solving, Communications of the ACM 39(4) (1996) 43–45.
[15] S.R. Hiltz, M. Turoff, The Network Nations, Human Communications via Computer, Cambridge University Press, Canbridge, 1993.
[16] E. Hutchins, How a cockpit remembers its speeds, Cognitive Science 19 (1995) 265–289.
[17] B. Jacobson, The ultimate user interface, Byte, 17 (4) (1992).
[18] M. Kyng, Making representations work, Communications of the ACM 38(9) (1995) 46–55.
[19] K.C. Laudon, J.P. Laudon, Essentials of Management Information Systems, Prentice Hall, Englewood Cliffs, NJ, 1995.
[20] J. Lave, E. Wenger, Situated Learning – Legitimate Peripheral Participation, Cambridge University Press, Cambridge, 1991.
[21] K. Lyytinen, R. Hirchheim, Information systems failure – A survey and classification of the empirical literature, Oxford Surveys in Information Technology 4 (1987) 257–309.
[22] J.C. McCarthy, V.C, Miles, Elaborating communication channels in conferencer, in: S. Gibbs, A. Verrijin-Stuart (Eds.), Proc. IFIP WG8.4 Conference on 'Multi User Interfaces and Applications, North Holland, Amsterdam, 1990.
[23] J.C. McCarthy, V.C. Miles, A.F. Monk, M.D. Harrison, Using a minimal system to drive the conceptual analysis of electronic conferencing, Unpublished Report, Department of Computer Science, University of York, 1991.
[24] J.C. Mingers, Information and meaning: Foundations for an inter-subjective account, Information Systems 5 (1995) 285–306.
[25] S. Minneman, The social construction of a technical reality, Unpublished PhD Dissertation, Stanford University, 1991.
[26] E. Mumford, The participation of users in systems design: An account of the origin, evolution and use of the ETHICS Method, in: D. Schuler et al. (Eds.), Participatory Design, Lawrence Erlbaum, London, 1993.
[27] N. Negroponte, Being Digital, Hodder and Stoughton, 1995.
[28] D. Norfolk, The virtual enterprise, Information Age November Issue (1995) 32–39.
[29] D.A. Norman, Cognitive artefacts, in: J.M. Carroll (Ed.), Designing Interaction – Psychology at the Human-Computer Interface, Cambridge University Press, Cambridge, 1991.
[30] C. O'Malley, S. Draper, Representation and Interaction: Are Mental Models all in the Mind? in: Y. Rogers, A. Rutherford, P.A. Bibby (Eds.). Models in the Mind, Theory, Perspective and Application, Academic Press, New York, 1992, pp. 73–93.
[31] O. Odegard, Social construction in virtual space, translation from Huordan Skapes Electronisk Kultur? Endrede vilkar – met datakommunikasjon, Proceedings of the Pedagosk Online Seminar (POS), Kjeller, Norwegian Telecom Research (Lecture F22/92), 1996.
[32] D. Patching, Practical Soft Systems Analysis, Pitman, London, 1990.
[33] S. Payne, On mental models and cognitive artefacts, in: Y. Rogers, A. Rutherford, P.A. Bibby (Eds.), Models in the Mind, Theory, Perspective and Application, Academic Press, New York, 1992, p. 103.

[34] R.D. Pea, Augmenting the discourse of learning with computer based learning environments, in: E. De Corte, M.C. Linn, H. Manol, L. Verschaffel (Eds.). Computer Based Learning Environments and Problem Solving, Springer, Berlin, 1992, pp. 313–345.
[35] R.D. Pea, The collaborative visualization project, Communications of the ACM 36(5) (1993) 60–63.
[36] J. Preece, Human-Computer Interaction, Addison Wesley, Reading, MA, 1994.
[37] H. Rheingold, The Virtual Community, Minerva, 1995.
[38] K. Rivera, N.J. Cooke, A.L. Rowe, J.A. Bauhs, Conveying information in remote computer mediated communication, in: C. Plaisarl (Ed.), Proceedings of the CHI 94 Human Factors in Computer Systems, ACM, New York, 1994, pp. 95–96.
[39] J. Singer, S. Behrend, J. Roschelle, Children's collaborative use of a computer microworld, Proceedings of the CSCW, ACM, New York, 1988, pp. 271–293.
[40] A. Strauss, J. Corbin, Basics of Qualitative Research, Grounded Theory Procedures and Techniques, Sage, Beverly Hills, CA, 1990.
[41] L. Suchman, Plans and Situated Actions, Cambridge University Press, Cambridge, 1987.
[42] L. Suchman, Representing practice in cognitive science, Human Studies 11 (1988) 305–325.
[43] J. Vaske, C. Grantham, 1990. Socializing the Human-Computer Environment, Ablex, Norwood, NJ, 1990.
[44] R.K. Yin, Case Study research – Design and Methods, Applied Social Research Methods, Sage, Beverly Hills, CA, 1989.