HCT – 2001

INFORMATION TECHNOLOGIES AND KNOWLEDGE CONSTRUCTION: Bringing together the best of two worlds

PROCEEDINGS

5th Human Centred Technology Postgraduate Workshop

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Brighton, U.K.

UNIVERSITY OF SUSSEX AT BRIGHTON

Organisers: Ben du Boulay, Claudia Gama, Miguel Garcia, Louise Hammerton, Anna Lloyd, Jonathan Matthews, Nuno Otero, Pablo Romero, Benjamin ZayaS

Sponsored by:

University of Sussex, School of Cognitive and Computing Sciences

Human Centred Technology Group

FOREWORD

This is the fifth in an annual series of workshops held in Brighton in the late autumn. They bring together PhD students from around the UK and from mainland Europe with a common interest in Human Centred Computing Technology. The diverse and interdisciplinary nature of this area can restrict opportunities available to students for peer review, feedback and discussion of the their work or the process of completing a thesis. These workshops give such students a chance to discuss their work and also hear presentations from leading academics and from leading commercial developers at the forefront of this field. The theme of this fifth workshop is "Information Technologies and Knowledge Construction: bringing together the best of two worlds".

Many people have been involved in the preparation for this fifth workshop. I particularly thank the workshop committee, Claudia Gama, Miguel Garcia, Louise Hammerton, Anna Lloyd, Jonathan Matthews, Nuno Otero, Pablo Romero and Benjamin Zayas. I also thank those who have helped in other ways such as Ann Light and Emma Whitcombe.

A special thank you is owed to Dr Rose Luckin whose idea it was to start this series of workshops and whose energy and vision have seen us through to now the fifth in the series.

All the above are members of the Human−Centred Technology group in the School of Cognitive and Computing Sciences (COGS) at Sussex. This group comprises faculty, research fellows and graduate students from COGS and other schools, interested in research on the design, implementation, and use of human−centred technologies. In particular, its main objectives are:

(i) to develop frameworks for understanding how people interact with and communicate through technology, and

(ii) to apply this understanding to develop and support innovation.

The group carries out research in a number of areas including:

- collaborative and networked technologies
- interactive learning environments and educational software
- intelligent tutoring systems
- intelligent agents
- interactivity, external representations, multimedia and virtual reality
- software design and reuse
- telematics and virtual collaborative environments
- ubiquitous and mobile computing
- visualization and medical information systems

Professor Benedict du Boulay
Leader of the HCT Group, COGS
September 2001

PEOPLE

Day One

How can Information Technologies influence the acquisition and organization of knowledge?

Guest speaker

To the Dynabook and Beyond − Designing Mobile Technologies for Learning
Professor Mike Sharples
School of Electronic and Electrical Engineering
University of Birmingham

Invited discussant

Professor Eileen Scanlon
Institute of Educational Technology
The Open University

Day Two

In which ways can models of knowledge inform the design and uses (or tendencies) of Information Technologies?

Guest speaker

Designing for Accessibility
Mr. Adrian Howard
QuietStars

Invited discussant

Dr. Kim Issroff
Higher Education Research and Development Unit
Education and Professional Development
University College London

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Session 1

How can Information Technologies influence the acquisition and organization of knowledge?

Pen-Based Digital-Document Technology

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Abstract

This paper highlights the ways in which current computer interfaces impair the capture and refinement of knowledge. It defines an interaction paradigm "informal interaction", and proposes that pen-based interfaces designed around the concept of informal interaction have the potential to overcome the current impediments. Finally, it identifies specific areas of research required to develop informal interaction pen-based interfaces.

Background

Knowledge work is dominated by the use of paper especially when capturing, organizing, and refining information [6][8]. Recent studies show that despite the recognized benefits of using a computer such as prototyping, document duplication, and error checking, computer literate professionals still prefer to capture and refine their ideas on paper. There is a gulf between the way humans express and manipulate ideas, and how computer interfaces require users to structure and interact with data [4].

An author's primary task is to express ideas. Computer interfaces require authors to explicitly define and structure their knowledge as they expressed it. These demands are premature and cognitively demanding, focussing the author on the interaction, not the idea. Consequently, many authors reject computer use and return to pen and paper.

Pen and paper constitute a mature and familiar interface for the capture and refinement of knowledge. Analyzing and identifying specific reasons for the use of paper will guide the development of computer interfaces that overcome current interface restrictions [8]. Introducing computer assistance to traditional pen and paper tasks can increase the efficiency of these processes [5].

The resemblance of pen-based computers to pen and paper suggests that these devices are ideal for implementing paper-like interfaces. Unfortunately pen-based computers currently fall a long way short of this goal. Pen-based computers commonly employ traditional WIMP-style interfaces, use handwriting recognition or on screen keyboards to replace typing, and follow the pen tip round the screen to simulate a mouse. The resulting interface is often cumbersome. Handwriting is slower than typing, recognition is far from perfect and requires frequent mediation, and a user's hand may conceal on-screen information when pointing with the pen. These interfaces also ignore the natural strengths of the pen: precision control; immediacy of expression; and direct manipulation.

Successful pen-based interfaces will be significantly different from familiar desktop computer interfaces. They will exploit the natural characteristics of the pen. Special attention must be given to *when* and *how* such interfaces will be used, or they will remain subordinate to paper.

Initial Findings

The creative phases, of capturing and structuring information and ideas, are not supported by commercial computer interfaces [4][9]. The capture of information is characterized by sketching and note-making activities, whether assimilating new information or transcribing mental knowledge [1][6]. The representations generated embody the most important concepts of the information and delay the specification of explanatory detail. Before an author invests time in producing a detailed description of his knowledge, he will try out, explore, and restructure his initial ideas and arguments. Commitment to a particular expression of his knowledge may come late in the authoring process.

We require computer interfaces that allow us to express and capture our ideas immediately. We need the ability to build on these ideas incrementally, reworking, restructuring, and reinterpreting them throughout the authoring process. We want to add detail and define formalisms step by step until we have captured and presented our knowledge in a refined and ordered way. This is the concept of "informal interaction".

Informal interaction was first defined by Moran et al. in 1997 [7]. Informal interaction is characterized by a modeless interface which combines freedom of expression with structured editing capabilities, and does not overtly engage the user in recognition mediation. Informal interaction occupies a conceptual void between free-form and formal interaction. Free-form interaction covers applications like a simple paint package that handles user input only on the level of a coloured bitmap of pixels, it may have many painting tools but their use has no semantic effect. Applications such as word processors are representative of formal interaction. Words are all members of a language set, and have other attributes and relationships to each other, such as titles, lists, and numbered paragraphs.

Informal interaction is founded on the assumption that during the phases of capturing and refining knowledge, an author can perform the tasks they want to with only a small set of general formalisms over the information they have expressed. As an author interacts with their creation, they can add more detail, and define and redefine their own formalisms. As the level of formalism increases, so does the logical merit of the information. Eventually a point is reached where a creation can be automatically imported into a formal application. This concept has been recently demonstrated in work by Gross and Do [3].

There appears to be a consensus in literature that the pen is the most natural tool for informal interaction, including both diagramming [2][3][5][6][7], and writing tasks [1]. Research has established pen-based informal interaction as a sound concept. This has taken place within the confines of specific applications. However there remain a number of challenges to be tackled to create a cohesive system that implements the informal interaction paradigm. These include, but are not limited to:

- Identifying and implementing basic sets of formalisms;
- Providing unobtrusive mechanisms to define new formalisms;
- Facilitating the transitions between levels of formality;
- Providing feedback to the user on the machine's current interpretation.

Future Work

Future work will be focussed on informal interaction with handwritten text. This will enhance diagram based applications, handling labels and annotations, and enable meaningful interaction with handwritten documents. Work already underway has assumed a notebook metaphor to guide the identification of basic formalisms. The word has been isolated as the basic handwritten textual entity. Implicit functions include moving, entering, and deleting words. The process of grouping words will define new formalisms over the data and mechanisms for doing this will be investigated.

It has been noted that text written directly onto a computer screen can be difficult to read. Handwriting recognition is not an option here since mediating the recognition process will distract the author and working with handwriting is inline with the informal nature of the interaction paradigm. Consequently work is progressing in the beatification of handwritten text. Experiments will provide a quantitative evaluation of algorithms to improve handwritten text legibility. Word segmentation algorithms will also be evaluated. Feedback to facilitate interaction may be given by applying legibility enhancement to segmented words.

Finally, working with large numbers of handwritten documents will require solutions to problems such as indexing, searching, and sorting. Algorithms that search handwritten text currently rely on searching an entire corpus for best-matches, or on recognizing words and then searching alphabetically. Both approaches are impractical on large amounts of handwritten data. Experiments are planned to evaluate algorithms that classify and match handwritten words. This will allow standard sorting and searching techniques to be employed on handwritten data.

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An Investigation into the Use of Mobile Computing Devices as Tools for Supporting Learning and Workplace Activities

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1. Introduction

Information technology devices are becoming increasingly portable, powerful and affordable. The use of computer technologies is no longer confined to desktop and office settings. Users now have access to highly portable and personal computing appliances, such as palmtop computers or personal digital assistants (PDAs), which they can carry around and use 'anytime, anywhere'. Such devices have a variety of functions; for example, they can be used to record data, to access information resources, and to communicate with other people. It has been argued, therefore, that mobile computing devices could be useful tools for supporting learning and workplace activities (Fung, Hennessy, & O'Shea, 1998; Hennessy, 1997, 2000; Sharples, 2000b; Soloway et al., 2001).

The central concern of my research is to determine how mobile computing devices, such as PDAs, can mediate learning and workplace activities, with the aim of identifying the benefits and limitations of using mobile technologies as learning tools. The research is grounded in activity theory, which provides a useful framework for examining and understanding the context in which a technological tool is used. A central tenet of activity theory is the notion that all human activity is mediated by the use of tools, both conceptual tools, such as language, and physical tools, such as technological devices (Vygotsky, 1978). The notion of tool mediation has particular relevance to this research project, and has been emphasised by activity theorists in the field of human computer interaction (e.g., Bannon & Bodker, 1991; Kaptelinin, 1996b). This paper will give a brief outline of activity theory, with an emphasis on the concept of tool mediation, followed by a description of initial empirical work that is currently being undertaken.

2. Activity Theory and tool mediation

Activity theory originated in Soviet psychology (Leont'ev, 1978; Vygotsky, 1978). The Russian equivalent of the term activity has connotations of 'doing in order to transform something' and it is this sense of the term that forms the basis of activity theory (Kuutti, 1996). According to Axel (1997), activity needs to be examined "in the broader context of how human beings in activity transform the world according to their needs and their needs according to the world." (p.129). In the case of computer tools, people transform the world by developing and using new technological devices that help to meet the goals of the activities they undertake. In addition, users may modify their needs and goals according to the capabilities and limitations of the technical tools they use. A primary aim of this research project, then, will be to examine users' perceptions of the benefits and limitations of mobile technologies, and to determine how activities, goals and user needs are restructured through the use of mobile computing tools.

The tool mediation perspective also emphasises the sociocultural context in which tools are developed and used (Vygotsky, 1978). The ways in which tools are used, and the settings in which they are used, are not static but instead evolve over time. Artefacts are shaped by previous experiences and constantly changed through activity (Bannon & Bodker, 1991). This developmental process is defined by Carroll *et al* as the 'task-artefact cycle' (Carroll, Kellogg, & Rosson, 1991). They propose that technological development involves a 'coevolution' of tasks and artefacts in which "an artifact suggests possibilities and introduces constraints that often radically redefine the task for which the artifact was originally developed." (p.79). The redefined tasks then create new needs and opportunities for further technological development.

Examining the use of new technologies, then, involves understanding their place in the task-artefact cycle. It also involves considering how the use of the new tool changes the activities for which it is used. In the case of tools that are used to access and distribute information, this may involve consideration of how the tool contributes to knowledge acquisition and dissemination. There are many examples from history of the development of new artefacts that changed the way people communicated, carried out work, and used information. For example, Saljo (1999) refers to the way in which knowledge was constructed and disseminated before the technology of writing was developed. As a tool, writing had a dramatic impact upon human activity and learning, and created an impetus for further tool development. Similarly, Fung *et al* (1998) speak of a 'paradigm shift' towards portable computing in education, likening it to the shift from reading as an activity that took place only in centres of learning to an activity that became an integral part of everyday life. The research described in this paper aims to conduct a systematic investigation to determine the nature of the 'paradigm shift' towards mobile computing. The study will consist of a series of investigations that will examine how mobile computing can be integrated into specific learning and workplace contexts.

3. Preliminary empirical work

The initial stage of the investigation consists of two pilot studies that aim to explore how mobile computing devices can be used to support learning and workplace activities. The studies are evaluating the use of PDAs in (a) a workplace context, and (b) a distance education context. These studies are briefly described below.

(a) An evaluation of PDAs in a work context

This study is investigating the initial impact that the use of PDAs has upon workplace activities. The primary aim of the study is to explore the ways in which PDAs can support various workplace activities, and to determine features of the devices (i.e., their capabilities and limitations) which impact upon their use. Twelve staff members from the Centre for Information Technology in Education (CITE), at the Open University, have been supplied with PDAs. Their use of the PDAs is being evaluated through various methods, including an email discussion forum, a diary study, observation, questionnaires and interviews.

(b) An evaluation of PDAs in a distance education context

This study will focus on the potential use of PDAs for reading electronic text. The primary aims of the study are to identify the benefits and limitations of using mobile technologies for reading, and to ascertain how the use of PDAs impacts upon the way in which reading activities are carried out. Open University students undertaking a Masters course in educational technology are participating in the study. Students have been supplied with a Palm PDA, with e-book reading software, and course materials for one study block have been made available for use through the PDA. Students' use and perceptions of the usefulness of the PDAs are being assessed through pre- and post-questionnaires and follow-up interviews. In addition an electronic discussion forum is being used to record students' comments about their use of the PDA during the evaluation.

The presentation will report initial findings from these studies and will conclude with an outline of issues raised for further investigation.

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Are Virtual Learning Environments being used to facilitate and support student-centred learning in Higher Education?

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Introduction

It would appear that the use of Web and Internet-based technology is ubiquitous in Higher Education in the United Kingdom. Advocates believe that the use of Web and Internet-based technologies in Higher Education can benefit students not only in their learning (Laurillard, 1993, Gibbs, 1999) but also in the transferable skills they will acquire as a result (Harrison, 1994). They also believe that this technology can facilitate and support the creation of student-centred learning environments (Collis, 1996) or a student-centred model of education (Westera, 1999). Student-centred approaches are advocated as a way of equipping students with the skills they need to survive in today's complex world. This research aims to investigate whether lecturers are actually using student-centred approaches, whether Web and Internet-based technologies can be used to support these and whether they cause lecturers to adopt more student-centred approaches. The research will focus on the use of Virtual Learning Environments (VLEs) specifically. Many institutions of Higher Education have adopted VLEs (either created in-house or purchased commercially) to provide their lecturers with an 'off-the-shelf' way of entering the online world.

Web and Internet-based technology and Virtual Learning Environments

Web and Internet-based technology ranges from synchronous and asynchronous collaboration tools to the Markup Languages (for example, HTML, VRML) needed to author documents. Chat, audio and video conferencing and using a shared whiteboard are examples of synchronous tools, where activity takes place in real time. Examples of asynchronous tools are e-mail, threaded discussions, noticeboards and document sharing, facilitating activities that take place over time and at a time convenient to the user. One manifestation of this technology is the package of integrated software tools termed a Virtual Learning Environment (VLE).

There is no universal definition of either a learning environment or a VLE. However, it is possible to construct a broad definition based on the literature (Britain and Liber, 1999, Firdyiwek, 1999, Stiles, 2000). A VLE is a learning environment where the necessary interaction and collaboration takes place in the virtual world of Web and Internet-based applications. The tools provided aid the lecturer in controlling and tailoring the virtual environment for use by their students, who are able to interact with, contribute to and move through the content. The main difference between a VLE and other computer-based learning or computer-supported learning environments is the possibility of communication and collaboration with peers and tutors within the same virtual environment that holds the content. The tools used include synchronous and asynchronous computer mediated communication software and those that enable the delivery of course materials online.

Web and Internet-based technology and Knowledge Construction

Many writers use constructivism to inform their discussions about Higher Education and the use of Web and Internet-based technologies (Bostock, 1998, Westera, 1999 and Morphew 2000). Constructivist theories of learning are also influential in the field of instructional design and development. Jonassen *et. al.* argue that there is a need for a constructivist approach to instructional design in Higher Education: “modern technology can and should support advanced knowledge acquisition. It can best do that by providing environments and thinking tools that engage constructivistic conceptions of learning" (1993, pg. 236).

Constructivism is "a collection of theories and ideas about different issues in pedagogy that are informed by a range of philosophical / epistemological outlooks" (Reibel, 1994, pg 1). There are different schools of constructivism but "a consensus would be that learners arrive at meaning by actively selecting, and cumulatively constructing, their own knowledge, through both individual and social activity" (Biggs, 1996, pg. 348). It is generally acknowledged that Web and Internet-based technology can be used to support this activity. For example, communication tools facilitate discussion and collaboration and it is possible to provide wider access to resources. Constructivism has elements in common with a student-centred approach to teaching which "sets out to start from where the learner is at rather than from the dictates of a prescribed curriculum" (Thorpe, 2000, pg.176). They both recognise that we learn from experience (Morphew, 2000) and that this helps us construct our own representation of knowledge (Dalgarno, 2001). Reflection and the reviewing of what is already known and what is learnt are also important.

Lecturers' approaches to teaching

The research will concentrate on the use of Web and Internet-based technologies from the lecturer's perspective. This is an important focus because it is the lecturer who chooses (within institutional limits), sets up and implements the learning environment for the students. Previous research has shown that lecturers' conceptions of teaching correlate with teaching approaches that in turn correlate with student learning approaches and learning outcomes (Kember, 1997 for an overview). Trigwell *et. al.* (1999) built on previous research to show that lecturers' teaching methods correlate with the approaches to learning of their students. It is widely argued that student-centred teaching approaches encourage students to adopt higher quality approaches to learning - what Biggs and Moore (1993) among others call a deep approach to learning - and aid the development of critical abilities.

Preliminary investigations

Preliminary investigations have involved semi-structured interviews with twelve lecturers across four institutions of Higher Education. These aimed to provide benchmark data about the factors influencing the use of Web and Internet-based technology. It was noticeable that the lecturers interviewed are considered innovators who are confident and well supported in their use of the technology. It was therefore difficult to find evidence to support claims made by the literature regarding factors that may impact upon the more widespread use of Web and Internet-based technology in Higher Education.

A constructivist framework was used to identify student-centred teaching approaches. This was based on Honebein's (1996) Seven Goals for the Design of Constructivist Learning Environments. Three main areas of Web and Internet-based technology use were identified: to hold and transmit content, to communicate and to aid student reflection and revision. There was evidence of student-centred methods such as group work being supported by the technology. Perceptions about the capabilities of their students and time to create materials or become familiar with software would seem to be the main inhibitors to use among this group.

Future research

The research questions identified so far are:

- Can Virtual Learning Environments support student-centred learning and how does the functionality of the system affect lecturers?
- What are motivating factors for lecturer use of Virtual Learning Environments and what prevents them being used?

- How are lecturers using them, what methods are they using, and how does this fit into their overall pedagogy?

Trigwell and Prosser's Approaches to Teaching Inventory (Prosser and Trigwell, 1999) will be used to capture lecturers' teaching methods. The focus will be on a particular subject area (Social Sciences or Humanities is suggested) to enable comparison across institutions and to move away from subjects such as computing that use the technology as part of their subject content.

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Session 2

How can Information Technologies influence the acquisition and organization of knowledge?

Searching for WISDeM, the Holy Grail of Intelligent Distance Education

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1. Introduction

This paper reports on an MPhi/PhD research project (end of its 1st year) into 'Virtual Universities' by the co-author W.A.Janvier B.Sc.(Hons). Initial research looked at current Distance Learning Tools (DLT) and Intelligent Tutoring Systems (ITS). It aims to bring together both areas for developing a KISS (Keep It Simple Stupid) generic Distance Learning Interactive Intelligent system. This project is a continuation of an ongoing research and development into Online Flexible learning since 1997 and builds on an earlier prototype [1].

2. The Ideal DLT

This project postulates that the '***Ideal DLT***' should be 1) a **W**eb **I**ntelligent **S**tudent **D**istance-education **M**odel (***WISDeM***) tool, 2) emulate learning 'in-situ', 3) support both the tutor and the learner by being able to replicate the tutor's advice and direction and 4) be able to function at some remote time every hour and day of the year. The system should exhibit benefits required by the 3 major stakeholders (Administrator, Author/Tutor, Learner) and offer the necessary Artificial Intelligence (AI) whilst maintaining at all times the KISS principle for all stakeholders: **ADMINISTRATOR:** *Technical Administration* should use the institution's own system with software installation and maintenance intuitive and time efficient, *Module System Administration* should be easy to manage from a web front-end with no technical knowledge required other than that of creating virtual address links using ODBC to the database, *Assessment Administration* should be automatic for both Question/Answer and text type replies: the former using AI and the latter Natural Language (NL) parsing with both being able to run qualifying examination papers taking cognisance of anti-plagiarism requirements, *Module System Administration* covers the creation, amendment and maintenance of the system files, folders and databases: **AUTHORING**, including Addition, Change and Deletion to module content, should be capable of being achieved using Word, Excel, PDF or any other preferred media simply by adding the required file to the relevant web folders. The system should be free of the requirement to use proprietary software but NOT restrictive of using (D)HTML, JavaScript, VBScript, ASP, SMIL, etc. or proprietary software. Interactivity using Forums, Feedback, Tutorials, Revision, Marking, analysing, etc should be easy to use and control via the *Administration Web* with assessment, grading and tracking users being automated as far as relevant, using autonomous agents [2]: **LEARNERS** should find the site intuitive to use with either an Intranet or Internet browser with the Ideal DLT encompassing: i) Self-Directed learning [3], ii) Asynchronous and Synchronous communication[4-6] and iii) 'Intelligent Interaction' to each learner's own profile. The site should be capable of dynamically changing as the learner develops, offering relevant links to library, system resources and World-Wide-Web sites, hints, structured answers, track every learner's progress and '*learn*' from the learner's usage and interactivity. A'Herran [7] provides excellent details of the usual DLT components.

2.1. Summary

In short, an ***Ideal DLT*** should offer all the facilities of the modern DLTs PLUS Intelligent Interaction whether the learner is a low or high skill learner [8]. The *Expert System* (ES) should wrap an intelligent cover around interactive learning modules creating an interaction between the learning modules and the intelligent tutor [9]. As the learner interacts with the DLT, the ES should watch how a learner proceeds through the material and learn what a learner knows, what a learner does not know, what a learner knows incorrectly and consequently what a learner needs to develop. The ES can take action autonomously or by request. It may, for instance, suggest that a learner go over additional specified materials or seamlessly introduce additional material into the current lesson. **WISDeM** is currently under construction, sans the Artificial Intelligence content, with evaluation starting in September.

3. Distance Learning

Computer Assisted Learning has been developing since the 1950's [3] with simple Linear Programs where the computer outputs text, the learner makes a response based on current knowledge, or by trial and error, and the computer responds with the correct answer [10]. The current vogue is to offer so-called Virtual Universities. Many universities are now recycling material, creating web sites and claiming delivery through a Virtual University [3]. The general accepted standard is that a learner must be able to experience Self-Directed Learning, Asynchronous and Synchronous communication. Christos Bouras et al [11] in their paper consider that '*Distributed Virtual Learning Environment'*, using a combination of HTML, Java and the VRML (Virtual Reality Modelling Language), makes acquiring knowledge easier by providing such facilities as Virtual chat rooms for learner-learner-teacher interaction, lectures using the virtual environment, announcement boards, slide presentations and links to WWW pages. Prof Linda Cooper [12] research shows that Post-secondary institutions want to offer on-line to meet the educational needs of a fast-paced, computer literate society. M Hegarty et al [13] provide a step-by-step guide for setting up distance learning classrooms using telecommunications technology.

4. Intelligent Tutoring Systems (ITS)

Tom Murray [14] postulates that while ITSs are becoming more common and proving to be increasingly effective, each one must still be built from scratch at a significant cost. Domain independent tools for authoring all aspects of ITSs (domain model, teaching strategies, learner model, learning environment) have been developed and go beyond traditional computer based instruction in trying to build models of subject matter, instructional and/or diagnostic expertise. They can be powerful and effective learning environments: they are very expensive in time and cost, and difficult to build. Thus, there are few ITSs that can be evaluated and generalization is difficult. To launch effective systems requires a paradigm shift from a 'story-boarding' to a 'data based' authoring paradigm. Fundamental is the separation of database content from *instructional methods*, where authors represent their knowledge explicitly and modularly, to *creating explicit representations* of the content and the instructional strategy. There is a major hold-up to AI work and the creation of computational models of instructional design theories: this is particularly acute in ITSs that incorporate rule-based representations of subject matter expertise [14]. Most computer tools and techniques that are used in intelligent interfaces stem from the AI field where 2 main areas come into play: *System User Modelling*, adaptable or self-adaptive and *Natural Language (NL) dialogue*. NL Programming has been a major area of research in AI ever since the early 1960s; however, the difficulty of parsing unrestricted learner input has not yet been satisfactorily solved. Guy A Boy [15] affirms that, whilst humans are capable of induction and handle imprecise data easily, computers are almost exclusively deductive systems and can only handle precise data well. Designing an Intelligent Assistant Systems (IAS) has five major stages: i) Discussing what is known, ii) Describing the languages for expressing this knowledge on a computer, iii) Determining which treatment processes are going to guide the program from start to end, iv) Programming the first version of the AIS and v) Incrementally evaluating the AIS. Steve Ryan et al [16] expects that ITS will develop so that instruction becomes more individualised and more conversationally informed. Intelligent Agents will converse with users, will get to know the learner, get to know what the learner wants to learn and build a profile of the user's interests.

5. Distance Learning and Intelligent Tutoring - WISDeM

Our research indicates that the GENERIC marrying of a DLT with an ITS using the WWW requires development and research. There is a lack of research linking knowledge contained in a DLT database, Tutorial HTML pages, hyperlinks and AI in a generic manner. Much research has developed WWW searching: Prof. Henry Lieberman [2] asserts that the many systems reviewed concentrate on WWW searching using "autonomous, interface and autonomous agents". Interestingly, since 1995, the Java Expert System Shell (JESS) has been being developed. Core JESS language is compatible with CLIPS, uses the Rete algorithm to process rules, adds many features to CLIPS, including backwards chaining, the ability to manipulate and directly reason about Java objects. The educational market requires a combination of DLT and ITS in order to achieve real success. Tom Murray [14], in common with many other researchers, believes that ITSs are too complex for the untrained user and that "*we should expect users to have a reasonable degree of training in how to use them, on the order of database programming, CAD-CAM authoring, 3-D modelling, or spreadsheet macro scripting*". This begs the question: **"How many lecturers have the required knowledge, or time, to develop a tutoring system that requires expert knowledge to use?"** Our research, with many lecturers at Liverpool John Moores University, suggests that there are very few. They would all prefer to use a system that evidences the KISS principle. The development of WISDeM proposes to be a generic KISS ITS using a new methodology. This will enable a DLT/ITS creation of Modules/Courses, which Modules, using Site/Folder/File Hierarchical structure Profiles, Tutor Pedagogical Profiles and Learner Profiles, will interact intelligently.

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I-Search: A Meta-tool for Novice Web Searchers

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1. Introduction

This research is a study for the design of a software tool to help 16- and 17-year-old college students become more proficient at searching the World Wide Web for information needed for their college work. Its aim is to help students acquire some of the skills required for independent research - i.e. working towards forming their own conceptions of knowledge - using the information technologies associated with the World Wide Web.

Many people are already efficient users of the current generation of browsers and search engines. But, for other people, searching the Web can be a tediously frustrating experience which is to be avoided if at all possible. This has been demonstrated both by informal personal contacts and by two questionnaires - one in the author's department at the University of Sussex and the other at Lewes Sixth Form College. In both questionnaires, people who had more experience with Web searching said they found it more easy than did people who had only had a little experience.

This is hardly surprising; practice makes perfect. But as any parent or teacher will testify, motivation, enjoyment and satisfaction are essential ingredients in encouraging learners to practice their emerging skills, and it is postulated that the current generation of browsers and search engines are not sufficiently "user-friendly" to encourage novice Web searchers to persevere and overcome the difficulties that will inevitably arise.

2. Outline of *I-Search*

I-Search will be a meta-tool (a tool for the use of other tools) that will accompany the novice Web searcher, guiding them through the stages of formulating their research question, extracting keywords, choosing a suitable search engine, constructing valid search syntax, browsing the results list, evaluating web pages for information quality , using browser facilities such as ‘Back', ‘Bookmarks', & ‘History', using recovery strategies when things don't go wrong, and concentrating on the task in hand.

The software will run in a separate window to the browser window, and will consist of two parts: on the left-hand side there will be a graphical overview of the various stages in searching, which will be represented as a series of interlocking cyclical processes; and on the right-hand side there will be a textual description of how to carry out the stage on which the user is currently engaged.

3. Theoretical Background

The design of ***I-Search*** has been informed by the psychological concept of ’metacognition’, and by information and library science.

Metacognition can be defined as ’cognition about cognition’, or thinking about thinking (Flavell, 1979). Various workers have proposed that the application of metacognition is particularly useful for learning ’higher-order’ skills such as reading, writing, maths, and general reasoning and problem-solving (Resnick, 1987, Gama 2001). When learning such higher-order skills, students can be taught metacognitive techniques - for example, monitoring one’s own understanding, imposing one’s own meaning and structure, asking questions about the presented material, and so on (Resnick, 1987), and these may improve their performance on the target skill.

Looking for research-related information, whether it is on the Web or in traditional libraries, can be regarded as another ’higher-order’ skill, for which metacognitive techniques may be useful; users can be shown how to reflect on, and become more aware of, their own cognitive role in the information-seeking exercise, to modify their thought processes and actions accordingly, and to develop their own repertoire of useful search strategies for their own domains of interest. However, one of the ways in which the Web and traditional libraries differ is that, through being well-established in culture and society, the library has had many tools developed to help the novice user - for example, verbal communication with librarians and teachers, cataloguing methods, library catalogues, floor plans and shelf maps, signposts and labels, reading lists, teaching materials, and so on. Assistive technologies for using the Web now need to be similarly developed:

> "The immediate overriding constraint of the Internet is the fact that few users have learned how to manipulate Internet tools with the same confidence that they can manipulate a library... The implications for instruction and performance technology in this context are obvious. Most of us learned how to use the Library when we were in school, and we learned by doing -- doing research. In the process of solving research problems we had the scaffolding of librarians and the coaching of good teachers. We suggest that Internet skills deserve a similar treatment. The power of Internet resources remains latent to those without the skills to use them. But who are the librarians in this virtual library? Who will provide the scaffolding and coaching for the unskilled researcher? Who will undertake the task of conjoining people and knowledge...? Who will classify knowledge and information? These tasks don’t go away in the virtual environment, but the agency of librarianship shifts from the center to the periphery. The role of virtual librarian is distributed. In the virtual library there is no central keeper of knowledge, only curators of particular views .... The role of organizing and classifying knowledge is passed to each user." (Ryder & Wilson, 1996)

4. More Detailed Description of *I-Search*

I-Search consists of a number of web pages written in html and php, with java and/or javascript where necessary. The graphical overview in the left of the window is a representation of four interlocking cycles of activity. The outer cycle represents the process by which a user constructs, and obtains an answer to, a particular research question; inside this is a cycle representing the formulation and refinement of keywords and construction of a syntactically correct query; next, there is a cycle which represents the browsing of web pages in a results list presented by a search engine; and finally the innermost cycle represents the following of interesting-looking links from one of the web pages in the results list. Each cycle can be repeated as many times as required. From all stages in all cycles the user can click on a ’STOP-search abandoned’ box, or a ’STOP - search satisfied’ box, or an ’Any Problems?’ box.

In the of the window is a verbal description of the particular stage on which the user is currently engaged, and, if appropriate, a box where they can type input. When the software is first invoked, the right of the window contains an introductory paragraph, and the user is invited to click to start. The user can then choose to continue working through the stages in sequence by clicking on the ’next’ button in each display in the right of the window, or they can skip to other parts of the search process by clicking on one of the boxes in the graphical representation in the left of the window.

5. Preliminary prototyping of *I-Search*

Software development began in summer 2001 and the initial prototype will be tested; firstly among friends and colleagues, to highlight any major problems in usability and/or functionality; and secondly among 16- and 17-year-old novice web searchers, to elicit suggestions for improving it so that it will appeal to these particular users, and be attractive and useful for them to use.

6. Proposed Evaluation of *I-Search*

The software will be evaluated using both qualitative and quantitative techniques. Quantitative methods will include a between-subjects controlled experiment using two groups of novice Web searchers; one group will use ***I-Search***, in addition to their usual browser and search engine(s), to conduct a small piece of research on the Web; and the other will carry out the same task without ***I-Search***. The speed and efficiency with which the users are able to locate useful resources on the Web will be measured by readings from computer logs, and the ease of use, enjoyment and satisfaction experienced by the users will be assessed by questionnaire. Qualitative methods will include semi-structured interviews and video analysis of searching sessions.

7. Conclusions and Summary

A software meta-tool, ***I-Search***, which aims to improve novices’ experience of searching the Web, is described. Development and evaluation will be carried out with the target user group, and the generalisability to other groups will be considered.

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Inside the Internet: A resource for teaching young people about the Internet

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Introduction

Alongside the ever-increasing prevalence of computers in today's society comes an implicit rise in the number of people using the Internet. This rise brings with it a more diverse group of users, which of course, includes children. In recognition of this, the Government's scheme (the National Grid for Learning) to educate the nation about the Internet has proposed a series of targets to be completed throughout 2002. The priority of this proposal is to connect all schools and educational institutions to the Grid via the Internet.

Previous research has shown that adults have a poor understanding of how the Internet works (Sheeran, Sasse, Rimmer & Wakeman 2000a & b). With this being the case, how do we expect parents and teachers to impart the correct information to children?

At present there are few, if any, available resources aimed specifically at educating young people (children). There are several tutorials aimed at helping people learn about the Internet, but few that are suitable for children. This resource aims to fill a gap, as any resource that is created for children to use in schools is much better than the situation as it stands at present, since there is nothing.

This research builds upon the work of Luckin, Rimmer and Lloyd (2001), and will be carried on to develop the resource further. The presentation will give an overview of work carried out in the development of the 'Inside the Internet' prototype.

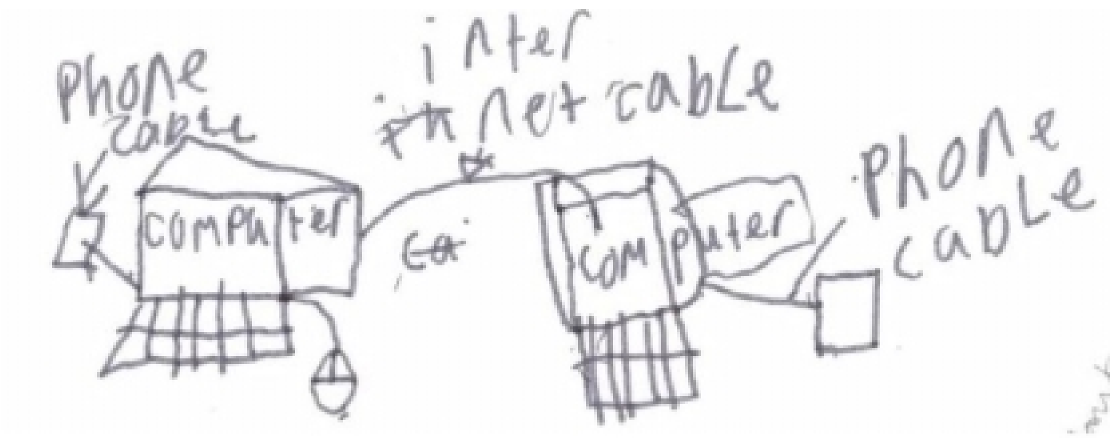
Aim

This aim of this study is to develop a resource to be used in primary schools as an additional teaching aid, to educate children about what the Internet is, and how it works. So far the project has completed two main phases. The first of these was a fieldwork phase during which vital information regarding the target user group was collected, as well information from computer experts concerning the technical details of the Internet. The second entailed the creation and testing of a lofi prototype version of the resource.

Phase 1 - Fieldwork

The purpose of this user study was to elicit information from the prospective user group of this resource regarding their knowledge and experience of computers and the Internet. To obtain this information, an investigation of children's mental models of the Internet was done by means of drawings and a simple questionnaire. It was hoped that by examining children's mental models of the Internet, a more detailed insight into their knowledge of the Internet would be obtained, as well as an indication as to where the gaps in their understanding exist. Drawing was chosen since it is a wholly more appropriate method for use with children. For them, drawing is more enjoyable and enables them to express themselves without being restricted by the barriers of language, or intimidated by the pressure of the being 'tested'.

Denham (1993) successfully used children's drawings of computers to investigate their mental models. She asserts that it is children’s lack of understanding of what computers are, and how they work that is preventing them from attaining the standards outlined by the Government for Information Technology (IT). She believes that children’s insufficient comprehension of computers has detrimental effect on their ability to use them efficiently and effectively. In support of this, and with relation to the Internet, Luckin, Rimmer and Lloyd, (2001) suggest that if children have an deficient understanding of the fundamentals of networked computing, they are likely to be less effective users of the Internet.



Example drawing from one of the young people.

Internet Afternoon

As an addition part of research of the users I attended, participated and observed an 'Internet Afternoon' as part of the Great Adventure Project (G.A.P.) for children over the summer holidays. Children spent the afternoon experimenting with a variety of both software and hardware. This enabled me to gain an appreciation of how comfortable and confident young people are with computers, and yet observe that, with respect to the Internet, children do not have a firm understanding as to what it is, never mind how it works!

Their conception of the Internet is very high-level, and appears to be based on the physical image that they see in front of them when they use the Internet. Their models of the Internet tend to comprise a stand-alone computer, with perhaps a website on the screen, or a desktop icon labeled 'Internet'. Other field trips were made and interviews undertaken with young people, teachers and even network experts in order to gather both user information as well as technological knowledge.

Phase 2 - LoFi Prototype

Having collected a plethora of information during the fieldwork phase, this information could now be used to develop a lofi prototype of the resource. The prototype testing showed that the fundamental design of the resource was successful. However, as expected there were amendments to be made. It became very clear that children need direction and a focus from the outset. Some pages of the prototype had activities on them such as correctly labeling a diagram, or solving a problem using the pictures given. Children preferred having small goals like this throughout, rather than just reading text and looking at a picture. The prototype will be presented during the talk, along with the main findings and future work.

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Testing the Effectiveness of Sonification for Learning Molecular Bonding and Structure in a Virtual Environment

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1 Introduction

This paper describes an ongoing research about developing and testing a multimodal virtual environment intended for learning abstract concepts in molecular biology.

Most chemistry students have great difficulty in learning abstract concepts in molecular biology, such as bonding and its relationships with molecular structure (Harrison & Treagust, 1996).

Molecules are composed of two or more atoms held by an invisible sharing (bonding) of electrons or ions, which have variations in length, number, and intensity, among other properties, and also they determine the shape of the molecule (Winter, 1994). Molecules are present at smallest microscopic scale. Typically, the size of small organic molecules, i.e. the amino acids, is in the order of 0.3 nm.

Thus, students have to figure out how the invisible and intangible properties of molecular bonding takes place and how properties interrelate, along with the molecular structure.

Surprisingly, most current molecular models used for teaching are not accurate and explicit enough to facilitate understanding of bonding and structure (Dor & Barak, 1999; Harrison & Treagust, 1996, pp. 514). For example, most ball-and-stick model sets lack in showing bonding order (the number of bonds between two atoms), not to mention partial bonding. Also, bond length and strength are misrepresented in this type of model.

Past research have proposed and tested virtual reality (VR) techniques and virtual environments (VEs) intended to ease students' learning in chemistry education. The particular characteristics of VEs are to provide enhanced 3D molecular representations and user interaction with the system. Chris Byrne's doctoral work was based on testing students' assembling of a virtual molecule of water, using an immersive virtual environment with haptic input. Byrne reported an increased students' engagement with the model. Also, Byrne found that students' interactivity with the system is the key for developing a successful educational virtual environment (Byrne, 1996). More complex computer interfaces for learning molecular properties have been developed recently. Project Sciencespace (Dede, Salzman, Loftin, & Ash,) is being testing multimodal computer interfaces (According to Blattner and Glinert (1996), the term multimodal interface "exploits multiple human sensory modalities in human-computer interaction") that allow students to interact with virtual molecules in an immersive virtual environment, by using their

sense of touch, and receiving informative feedback through vision and sound. Early studies of Sciencespace reported increased students' attention and engagement.
This research suggests that presenting visual and auditory information at a multimodal virtual environment is an effective way to convey molecular bonding.
The purpose of using sounds in this research is twofold:

- Using sonification (mapping sound properties of pitch, timbre and amplitude onto scientific data) as feedback on building a virtual molecule.

- Using earcons or auditory icons (abstract or natural sounds that convey a message) to encode extra information on bonding.

Both ways of presenting sound accomplish the same objective: To provide the student with complementary information to visualisation of bonding and structure properties, as an attempt to make bonding more understandable.

2 Rationale

This research is based on previous studies about applications of multiple channels of information within virtual environments used for learning in science education (Dede et al., ; Byrne, 1996). It has been proposed that multimodal VEs ease the interaction between the student and the computer interface by providing visual, auditory and tactile feedback. Also, the interface can present extra information in more than one information channel (i.e. vision, hearing and touch), with the objective to reinforce, complement or supplement information from one channel to another. This multimodal integration could facilitate the distribution of attention and engagement when students perform activities within the virtual environment (Dede et al., ; Winn, 1993; Youngblut, 1998).

3 Hypothesis

The hypothesis of this research is that using auditory display and visualisation techniques for representing bonding properties in a virtual environment is an effective way to facilitate students' understanding of molecular bonding and structure.

4 Proposed Virtual Learning Environment

A Desktop virtual environment is being developed, consisting of a SGI workstation and a virtual reality world made in DIVE (Distributed Interactive Virtual Environments). Students will interact with the VE using a 6DOF mouse (a Spaceball) to rotate and position the virtual atoms. Also, the computer will display the VE in stereo, and students will visualise the molecules through a pair of shutter glasses.
Along with the virtual system development, an exploratory experiment is being designed to test the usability of the system, in which the main task will be the students' construction of a virtual molecule. The VE system will provide the student with auditory feedback on the assembling of the molecule and extra information on bonding properties, along with visualisation of molecular structure.

5 Conclusion

This paper briefly described an ongoing research about testing a multimodal virtual environment intended for learning molecular bonding. Further studies are needed to determine how the bonding concept is to be encoded into visual and auditory information.

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Choosing a challenge: Exploring learners' ability to reflect on their own needs.

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Introduction

Traditionally software scaffolding has been employed within interactive learning environments (ILE) to offer a means of enabling the learner, or group of learners, to achieve success beyond their own independent ability. A vital feature of successfully scaffolded interactions is that the learner can recognise but not produce the goal. In order for this to be realised the system must make provision for the amount of support it gives the learner to be reduced or *faded* once she is able to work more independently. The importance of this is integral to the Vygotskian theoretical foundations underpinning software scaffolding [1]

Whilst the importance of being able to fade scaffolding is clear, the best means to achieve this successfully are less well understood. Such fading can only be brought about by the system either maintaining a model of the learner and making the fading decisions based upon this or by the system providing learners with enough and appropriate information to enable them to fade the support for themselves. Allowing the learner more control encourages independent learning and reflective awareness, it also recognises the difficulty of building effective, efficient and appropriate models of learners [2]. An approach which attempts to design adaptable interfaces which offer learners guidance and the tools to make decisions for themselves also addresses the importance of maintaining the fine balance between system guidance and learner control [3]. This balance is difficult to achieve, not all learners are good at assessing their needs or finding and using help for themselves. In particular, evidence from previous research into learners' use of scaffolding assistance has indicated that less able and knowledgeable learners are ineffective at selecting appropriately challenging tasks and seeking appropriate quantities of support and guidance [4] [5].

The Ecolab

The Ecolab is an interactive learning environment that presents children aged 10-11 years old with a simulated Ecology Laboratory. The software in its current form offers the child facilities to build, activate and observe the relationships that exist between members of a food web. The Ecolab has a strong student model, which quantifies the help used in conjunction with the difficulty of the tasks tackled. At present, the software has been implemented following a design framework that incorporates domain level scaffolding, combining learner focused and task focus scaffolding but largely ignoring metacognitive issues [4].

Research Aim

The aim of our research is to combine the Vygotskian theory that underpins scaffolding with participatory design to address the development of young learners' metacognitive skills, focussing on how we can make learners more effective at reflecting on their own needs, at choosing challenges and suitable assistance.

Early Studies

When using design techniques that involve the users of the actual system being developed it can be difficult to communicate thoughts and ideas, especially when the end users of the system are children. Children are often easily intimidated and can feel that they are being tested. We have been very fortunate to have a good relationship with a local primary school and have been working closely with a class of year 6 children since autumn 2000.

We have used a participatory design approach, integrating a variety of techniques to assist and involve the learners in the design process. Much of our early work concentrated on making the children feel comfortable talking about their attitudes to, and knowledge of the need to take on a challenge and to ask for help when they need it.

Focus on help

Analysis of our early research was useful for indicating the way in which the children accessed help and at what points within a task they required help [6, 7]. However, the studies were always run within the domain of food chains and food webs. Although this is the context provided for our research, individual children may react differently in different contexts and as our aim is to develop a metacognitive framework we designed a study to take into account differences in children's help seeking behaviour within different domains.

Pen and paper tasks were used to gather information in two parts. The first part of the study required the children to answer a questionnaire designed to illustrate their attitudes to help in general, not specific to a context. In the second part of the study, specific examples of tasks from different disciplines were collated. For each task the children were shown the answer and were given 5 different clues that they had to rate in helpfulness. The clues were developed following Wood's contingent strategy of 5 levels of control [8]. The helpfulness was rated using a 5-point Likert scale, ranging from 1: *Not very helpful will need another clue*, to 5*: Very helpful will get the answer*.

The results from the help attitude questionnaire revealed that almost an even number of children liked/did not like to ask for help (55%/45%). The reasoning behind their preference varied. Three quarters of the children who liked asking for help said that it was because they wanted to improve their own performance speed, the quality of their work, or the completeness of their work. Of those children who did not like asking for help just under a third (31%) preferred to try and work on their own. Just under half of the children who did not like asking for help (47%) gave personal reasons such as shyness, embarrassment when asking for help, worry about how asking for help looks to other people.

The most popular forms of help were 'general encouragement', 'something that gives you confidence' and 'clue that will help me get the answer on my own'. The majority of the children wanted help to be on hand: *'when I don't understand what I am being told to do'*.

Although the helpfulness ratings given to the 5 clues varied slightly depending on the domain of the task given to the children the 4th clue was rated as the most helpful overall (all 4th level clues identified the specific elements of the task solution). The results from both parts of the study showed consistency as the ratings chosen for a clue were related to the type of clue that the children had said that they preferred.
Further explanations and details of the findings will be presented at the workshop.

Representation
In our most recent study, we have switched our focus to the question of how best to represent the help, challenge and task selection options on screen. The study is paper based and offers children alternative representations for activity selection, challenge selection, accessing help, help selection. The representations vary in terms of their use of colour, shape, number, letter, text, positioning of elements, etc. Our analysis of these results will be discussed in the presentation.

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Investigating the Effects of Training in Metacognition in an Interactive Learning Environment: Design of an Empirical Study

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Abstract: This paper describes the design of an empirical study that investigates students' interaction with a problem−based learning system that presents reflective activities. The system is called *The Reflection Assistant* and it is in its design phase. The system and the experiment are part of ongoing research on the role of metacognitive awareness on the learning processes in problem solving environments. The research is based on the hypothesis that through reflective activities students can improve their metacognitive skills and thus perform better when engaged in problem−solving tasks in the same domain and also transfer to other related domains.
Keywords: *metacognition, problem solving, reflection, computer science education.*

1. Introduction

Recently, many studies have examined ways in which metacognitive theory can be applied to education, focusing basically on the fundamental question "*Can instruction of metacognitive processes facilitate learning?*" (Hacker, 1998; Hartman, 1998). The literature points to several successful examples (see Hacker, Dunlosky & Graesser, 1998 for more details).

This research investigates the proposition that metacognitive skills can be trainable if they are articulated and practiced under circumstances which require them to be used. Some researchers (Derry, 1992; Salomon and Perkins, 1989, for example) argue that metacognitive skills have to be taught embedded within a content area to provide the appropriate environment in which it is possible to cultivate and apply the skills. A related issue investigated in the scope of this research is that improvement in students' metacognition leads to better cognitive performance. Previous studies show that making students reflect on their thinking through metacognitive questions results in improved task performance in problem−solving situations (Dominowski, 1998).

This paper describes the initial design of an empirical study that investigates the above propositions in the context of a computer−based problem solving environment.

2. Goals of the Empirical Study

The major aim of the empirical study is to analyse the effects of teaching metacognitive skills in a computer−based learning environment called *The Reflection Assistant*. The domain chosen for this experiment was theory of computer science, more specifically, topics related to finite state machines. The system presents problems and triggers the use of certain metacognitive skills through reflective questions and activities. Thus, the experiment investigates the impact of the tutorial assistance on students metacognitive skills, as well as the effectiveness of the reflective activities when they are engaged in problems related to the topic. There are several metacognitive skills that can help students in a problem solving situation. For this research, eight metacognitive skills were selected. Table 1 presents a description of the metacognitive skills chosen.

3. Hypothesis

The general hypothesis of this research is as follows: "The development of a conscious model of the metacognitive skills used in problem solving can improve students' performance on problem−solving learning environments". This statement has to take into account the differences in students' learning styles, and initial cognitive and metacognitive abilities. Also, it is important to differentiate students' improvements in the domain trained and the transfer for new problems in another domains. Then, the working hypothesis put forward for this study is:

Students in an experimental group using reflective tools will increase their metacognitive skills and performance whereas students in a control group without such tools will keep their metacognitive skills in the same level, but possibly will increase their performance.

Metacognitive Skills	***Description of Metacognitive Skills***
1: Awareness of own level of understanding of the problem	It relates to an individual's awareness (or judgment) of the degree of understanding he has of the goals and the description of a problem.
2: Awareness of own intellectual strengths and weakness	It relates to awareness of one's abilities to solve a problem.
3: Awareness of previous knowledge	It relates to the ability for bringing to mind previous knowledge related to the present situation. In the context of problem solving, it comprises the ability of recalling previous problems with similar features.
4:Regulation of previous knowledge and use of similar problems	It relates to the ability for using previous information and knowledge in a new learning situation. In a problem−solving situation it occurs by comparing previous problems to a current one.
5: Regulation of strategies	It relates to one's ability to think about strategies that worked in the past for similar situations and consciously apply those strategies.
6: Regulation of actions / Ability to stablish, follow and update a plan of actions to solve the problem	The plan comprises goal setting, definition of steps to be taken towards the goals, time setting, and selection of strategies to be used. It relates to one's ability to foreseen the actions that can lead to the successful accomplishment of the problem. The plan needs to be evaluated and updated according to the partial outcomes of previous actions.
7: Evaluation of the steps taken towards the solution	It relates to one's ability for keeping track of how well he is performing a learning activity. It is an evaluation of the actions taking into account the goals set.
8: Evaluation of the effectiveness of the strategy choice	It refers to individuals' judgment about their learning experience.

Table 1 − Description of metacognitive skills chosen

4. Experimental Design

Participants: All subjects will be first−year undergraduate students enrolled in the Foundations of Computer Science Course (see **Table 2**).

Group 1: Experimental Group	10 subjects	Training in Finite States Machines and Formal Languages using the system **AND** the reflective tools
Group 2: Control Group	10 subjects	Training in Finite States Machines and Formal Languages using the system, **BUT NOT** the reflective tools

Table 2: Subject Groups

Procedure: The experiment will be divided into 4 phases:

(1)Pre−assessment Phase: The result of the pretest will be used to determine an initial profile of the students and it will de used to select those who will participate of the training. Students classified as "Low Metacognitive" and "Low or Average Performance" will be invited to participate of the other phases of the experiment.

(2)Familiarization Phase: This phase will be made up of one introductory session to show students how the system works.

(3)Metacognitive Training Phase: This phase is composed by three sessions where subjects will solve problems. The differences between the group that will use the reflective tools (experimental group) and the group that will not use the reflective tools (control group) will be observed. It is believed that two types of changes will be noticed on students: quantitative and qualitative changes. The quantitative changes expected are related to the amount of time spent on reflective activities, on planning, on evaluating their performance, and on the number of problems solved correctly. The qualitative changes will be viewed on reflective behavior, such as planning in detail their actions, selecting previous similar problems, including new types of strategies in their repertoire of strategies, etc. It is hypothesized that some individuals will learn more than others from interaction with the system. Then, an important point to investigate is what it was that the most successful individuals did (or which activities they engaged in) compared to the less successful ones.

(4)Post Test Phase: It will assess again students' performance.

Data: The data that will be collected are of two types:

(1) Quantitative Data:

- Time: total time per problem, time on pre−reflection and time on post−reflection.
- Number of problems solved correctly Vs. level of difficulty of the problem.
- Number of strategies selected per problem Vs. level of difficulty of the problem
- Number of new strategies included in the list of strategies.
- Number of relevant comments associated with each problem.
- Number of similar problems searched per problem Vs. level of difficulty of the problem.

(2) Qualitative Data:

- Efficiency of tool usage: build complete plan, make use of similar problems, apply strategies that have selected previously, etc.
- Reflective activity level: reporting pre−reflection and post−reflection in the interview at the end of the experiment and following the reflective hints given by the system.
- Consistency of metacognitive behavior: systematic approach to reflective activities, show general understanding of the purpose of the training.

5. Conclusions

Understanding how technology can best support student learning in diverse classroom settings remains a crucial line of educational research. The argument underpinning the experiment described here is that technology should help students to develop their metacognitive skills as well as their cognitive ones. The main contribution expected from this research is to provide a better account of the types of metacognitive reflection and level of students' metacognitive awareness and its influence on the learning processes in problem−solving contexts.

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Session 3

In which ways can models of knowledge inform the design and uses (or tendencies) of Information Technologies?

Knowledge Management in Virtual Environments

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Keywords: Knowledge Workers, Knowledge Representations, Distributed Organisations, Computer Mediated Communication (CMC), Computer Supported Cooperation in the Workplace (CSCW), Shared Understanding, Common Ground Approach.

1. Introduction

Knowledge is power. It has become the product of the modern office and the information, the primary raw material. Knowledge flows among human and organisational knowledge processes and structures that are the key to organisational performance. Tacit knowledge, that exists either in the minds of the knowledge workers or in a meeting within an organisation, needs to become explicit and available for many people to use and apply. Knowledge management strategy can support this objective if its development has been based on the understanding of the organisation in which it is applied. This understanding includes the organisational culture, processes the infrastructure as well as the human communication. Knowledge management should be able to encourage the communication among the people within an organisation for the creation and sharing of knowledge, rather than being a collection of individual's knowledge, especially when the organisation is distributed. The aim of this research is a further study on how can technology help distributed organisations extract knowledge from human communication among mobile knowledge workers by establishing common understanding in physical and mediated spaces and what are the necessary metaphors in such an environment.

2. Research Issues

The starting point of this research is the distributed organisations. A distributed organisation consists of individual branch offices that operate at a distance from the home office but are in fact intact sub-organisations with dynamics of their own. Virtual environments are a step further than that. They are dynamically created workspaces with members from widely dispersed locations who may operate in physical isolation from their colleagues. So when virtual environments are adapted in distributed organisations at the same or different space, at the same or different time there are same or different processes that are happening and the same or different people are involved in these processes.

This research is focused on the knowledge that is created within these environments. And it could be either individual or group considering its creation by a person or a team, and tacit or explicit considering its nature if it exists in the minds of people, it is internalised, verbal, soft knowledge or it is externalised, documented knowledge. The more representative vehicles of knowledge are mobile knowledge workers. These are experts within an organisation. There is increased demand for them but they are never in place because of the nature of their work. So they need different ways to communicate with their colleagues in order to help with their expertise or participate in meetings. This communication produces new knowledge about the subject that is discussed.

3. Research motivation

But why do we want to manage knowledge? Because Knowledge is Power (F. Bacon). It is the main capital of an organisation. And why do we want to manage this knowledge, the knowledge that comes from what people experience from communication? Because the only source of knowledge is experience. (A. Einstein).

A part of organisation's knowledge is experience. But *"an organisation's knowledge walks out of the door every night – and it might never come back.*" So, In order to acquire this kind of knowledge we need help. And the help in this case comes from technology. So, the main research question is "How can technology help distributed organisations extract knowledge from human communication among mobile knowledge workers?"
There are some sub-questions that arise from the main research question:

- When people communicate, either in physical or in mediated environments, they need to understand each other. So we need to identify how people establish common understanding both in physical and mediated spaces.
- The communication through computers is called Computer Mediated Communication. The question here is how can this communication help people to identify and acquire knowledge.
- A group of knowledge workers working together can be called Human Knowledge Community. These people sometimes need to use metaphors in order to pass quickly or more comprehensive their messages to the others. So what are the metaphors and the environment that need to be used so that a Human Knowledge Community can operate.
- Technological media tend to limit the communication comparing to the face to face communication as the last is a complex multi-modal process. So the question is how technology should be designed so that it adapts to the needs for identifying and acquiring knowledge.

4. Literature
In order to answer these questions research has been done in the literature starting by Knowledge Management and the several phases of knowledge life cycle, which according to Abecker and Bernardi *are*: identification, acquisition, development, dissemi-nation, use and preservation of enterprise's knowledge. In this research I am specifically interested in the identification and acquisition. How knowledge can be identified and acquired during communicative events.

This question arise the need for the next research in literature to be in communication and the time/space matrix which classifies communication according to the time and place the participants take part in the communication. So, a face to face communication is synchronous co-located because it happens at the same time and place while communication through letter is asynchronous remote because it happens at different place and time.

Still in communication, a cooperative work framework based on the entities involved in cooperative work, that is the participants and the things they use. People communicate directly or through artefacts and establish common understanding. When the communication is through artefacts then the participants control the artefact and take feedback by it.

The next area of research is the Computer Supported Cooperative Work. It is about group of users – how to design systems to support their work as a group and how to understand the effect of technology in their work patterns. These systems are called groupware and their function is to support computer-mediated communication through participants. Examples of such systems are email, videoconference and meeting rooms.

Virtual reality is an example of a meeting room where it is interesting to identify how participants realise time and space and what kind of metaphors they use in order to represent meaningful components. An example of a virtual reality world is a 3 dimensional chat rooms.

5. Methodology

It is clear enough that in order to identify the knowledge that is created during a communicative event we need to understand the human communication. For this reason the Common Ground Framework is used. The main principal of this framework is that people who communicate need to achieve shared understanding and this can be achieved by creating a common ground. The common ground framework consists of three main concepts:

- The Background Knowledge that is what people know or assume for the communicative event and the other participants. It is the soft knowledge that exists in the minds of the participants.
- The current state of Join Activities that is what is actually happening now in the present, where is it happening, who is participating and what is said.
- And finally the public domain resources which are the tools that people use to communicate, the shared artefacts. It is the hard, documented knowledge as well.

During a communicative event, the background knowledge feeds the current state that changes the public domain resources. These give feedback to the current state that changes the background knowledge of the participants. This cycle is repetitive during a communicative event until the participants end with shared understanding.
The process is like acting and experiencing.

6. Data Sources

The data sources for my research come first from workplace studies. These give us critical information about how people communicate in specific work settings: who the participants are, where and when the communicative event is taking place, what the topic and purpose of the event are and what media for communication are available in the work setting. This makes it possible to identify and describe the regularities and constraints that govern behaviour in those settings. And the other data source is work within the SANE project. SANE stands for Sustainable Accommodation in the New Economy. It is a multidisciplinary EU funded project to develop and validate a framework for the design and validation of sustainable workplaces that support knowledge workers in the office at home and on the move (SANE IST 2000-25257).

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Comparing The Effects Of Various Instruction Methods On The Acquisition And Retention Of Laparoscopic Knot Tying Skill.

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Background: Laparoscopic surgery is becoming increasingly popular, reducing expense and trauma of procedures and, allowing previously non-feasible procedures to be performed [1]. Yet, there is uncertainty as to how to promote the psychomotor adaptation and learning of skills required, as they differ to those of open surgery. Satava viewed laparoscopic surgery as a transition technology that marked the beginning of the information age revolution for surgery [1]. Knowledge of how humans learn and, content quality, must make best use of the more sophisticated tools available. The use of virtual reality trainers and simulators is becoming increasingly popular in medical education and knowledge of human learning of appropriate tasks is worthy of consideration in the design of such technology. This study forms part of a series that considers psychological principles of learning, in designing the training of laparoscopic knot tying skill. Laparoscopic knot tying is a difficult skill to master but research and surgeons alike agree on its importance as a training tool, as it enhances psychomotor dexterity, general laparoscopic skills and surgeons' confidence [2, 3]. How a task is initially presented to a novice may influence how well it is learned, as this is when learners begin to develop a basic mental model of how to perform the task.

Aim: To compare the influence of different instruction methods on the learning (acquisition and retention) of laparoscopic intracorporeal double-reef knot tying skill.

Method: 34 medical students (i.e. laparoscopic novices) were assigned to one of four instruction conditions, based on psychological learning theories. In each condition the knot was shown and described to the student in different ways (*Group 1 – complete knot*: video and diagram of complete knot; *Group 2 – forward chained:* video and diagram of knot shown in cumulative stages, from beginning to end; *Group 3-backward chained*: video and diagram of knot shown in cumulative stages from end to beginning; *Group 4- outside trainer*: demonstration and diagram of complete knot). Groups 1-3 saw the knot being tied inside the trainer, Group 4 outside. Students then attempted ten knots at a first training session *(acquisition phase)* and five knots at a later session *(retention phase)* with no practice in the intervening period. Data was analysed for number of knots completed (n) (KC); time taken to complete the halfway point of the knot i.e. stage 4(seconds)(T(a)); time taken to complete the knot tying trial (seconds) (T(b)) and highest stage (S) achieved during the attempt (knot comprised 8 stages).

Results: Group means showed that overall, group 4 tied the most knots (mean 11.6, SD 0.23), had the fastest T(a) (mean 74.8s; SD 44.56), the fastest T (b) (mean 166.9s, SD 62.55), and, achieved the highest S scores (mean 6.8, SD 0.8). Group 3 had the next best scores for all measures, followed by group 2 & group 1. Trials were grouped into three blocks of five for closer analysis of changes over trials (1-5= early acquisition; 6-10 = late acquisition; 11-15= retention). Only groups 2 & 4 consistently improved from block 1, to 2, to 3, for all performance measures. However, group 4 always had the best mean scores, followed by groups 3, 2, & 1. A two-factor ANOVA and greenhouse-geisser test showed significant within group differences over the fifteen trials, for each of the four measures. While there were some significant differences between groups (one-factor ANOVA & Kruskal-wallis test), within individual trials for various measures, no particular pattern emerged. A two-

factor ANOVA showed no significant difference between groups on any of the performance measures and, no significant interaction between group and trial.

Discussion: All four methods showed significant improvements in performance across trials and there was no significant skill loss over the period of no practice. In theory then, any of the four methods are plausible instruction methods. Demonstration outside the trainer led to better results than inside trainer, although this effect was not statistically significant. However this may suggest that viewing gross motor movements (hand and arm) in a model is helpful when learning laparoscopic knot tying.

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Comparing The Effects Of Different Part-Task Instruction And Practice Methods, On The Acquisition And Retention Of Laparoscopic Knot Tying Skill.

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Background: Laparoscopic surgery is becoming increasingly popular, reducing expense and trauma of procedures and, allowing previously non-feasible procedures to be performed [1]. Yet, there is uncertainty as to how to promote the psychomotor adaptation and learning of skills required, as they differ to those of open surgery. Satava viewed laparoscopic surgery as a transition technology that marked the beginning of the information age revolution for surgery [1]. Knowledge of how humans learn and content quality must make best use of the more sophisticated tools available. This study forms part of a series that considers psychological principles of learning, in designing the training of laparoscopic knot tying skill. The use of virtual reality trainers and simulators is becoming increasingly popular in medical education and knowledge of human learning of appropriate tasks is worthy of consideration in the design of such technology. Laparoscopic knot tying is a difficult skill to master but, research and surgeons alike agree on its importance as a training tool, as it enhances psychomotor dexterity, general laparoscopic skills and, surgeons' confidence [2,3]. Of particular interest to the current research is whether part- or whole-task training is more beneficial. Part-task training tends to be more beneficial for tasks high in complexity (many sub-parts) and, low in organisation (parts loosely related to each other); the reverse is true for whole-task practice. The main types include: *fractionisation* (parts of the task having critical relationships with each other combined); *segmentation* (progressive cumulation of parts e.g. forward chaining, backward chaining); *simplification* (removing one or more elements of difficulty of the task).

Aim: To investigate which part-task instruction and practice method is most beneficial in the learning of laparoscopic intracorporeal double-reef knot-tying skill.

Method: 32 medical students (i.e. laparoscopic novices) were assigned to one of four part-task practice conditions, based on psychological learning theories. Presentation and practice of the knot was varied between conditions. All students viewed demonstrations, then practiced the part of the knot they had just seen, until all parts were completed: *Group 1 – forward chained:* video and diagram of knot shown in cumulative stages, from beginning to end; *Group 2-backward chained*: video and diagram of knot shown in cumulative stages from end to beginning; Group 3- *fractionisation*: video and diagrams of parts of the knot having critical relationships with each other shown; *Group 4- Simplification*: demonstration and diagram of complete knot outside the trainer. Groups 1, 2 & 3 practiced inside the trainer, group 4 outside. Students attempted ten knots at a first training session *(acquisition phase)* and five knots at a later session *(retention phase)* with no practice in the intervening period. Data was analysed for number of knots completed (n) (KC); time taken to complete to the halfway stage of the knot i.e. stage 4 (seconds)(T(a)); time taken to complete the knot tying trial (seconds) (T(b)); and highest stage (S) achieved during the attempt (knot comprised 8 stages).

Results: Group means showed that the group 3 tied the most knots (mean 13.5, SD 0.17), had the fastest T(a) (mean 52.3s; SD 22.23), the fastest T (b) (mean 117.8s, SD 48.9), and,

shared the highest S score as groups 1 & 2 (mean 7.1, SD 0.45). Group 1 had the next best scores for all measures, followed by group 4 on T(a), but by group 2 on T(b). Within each block, group 3 always had the best mean scores. The fifteen trials were grouped into three blocks of five for closer analysis of changes over trials (1-5= early acquisition; 6-10 = late acquisition; 11-15= retention). Only group 3 improved in all performance measures from block 1, to 2, to 3. Group 3 also had the best scores in each block, for all measures. A two-factor ANOVA and greenhouse-geisser test showed significant within group differences over the fifteen trials, for each of the four measures. A one-factor ANOVA and Kruskal-Wallis test showed some significant differences between groups within individual trials for various measures but no particular pattern emerged. A two-factor ANOVA showed no significant difference between groups on any of the performance measures and, no significant interaction between group and trial. A one-way ANOVA showed significant differences between groups for time taken to complete the part-task practice before knots were tied ($f(3, 31) = 6.276$; $p<0.01$) and, group 3 took least time of all groups.

Discussion: All four methods showed significant improvements in performance across trials and, there was no significant skill loss over the period of no practice. Group 3 led to the best result's although not significantly so. It took significantly less training time than the ˝ other ˝methods. This could be beneficial in time constrained ˝conditions such ˝as training courses and, in theatre – giving equal or better returns for time spent ˝training.

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Interfacing experience: An activity theoretical approach to HCI for online grocery shopping, through consideration of the salient sensory attributes of products.

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Abstract: The way people can evaluate product characteristics on the Internet, varies considerably from the ways people observe, handle and try in physical environments. This is due to the lack of interaction with the product, which cannot be evaluated on-line, as consumers cannot use their senses to physically inspect the product. This research seeks to illustrate the implications of the sensory activity of shoppers on-line, starting from an analysis of shopping for food from an Activity Theory Perspective.

The activity of shopping for food, is one which has developed over recent centuries and the ways in which people experience this process have changed considerably within their cultural, social, economic and historical contexts. A great deal of academic and market research has sought to understand and even shape these experiences and the activity of shopping itself. Important aspects of these experiences, are the ways in which people use their senses and experiences as knowledge, to evaluate and choose products. Indeed, the use of the senses is prevalent in determining the very nature of the grocery shopping experience, with salient product attributes providing a source of sensory stimulation to the shopper.

The emergence of new ways of shopping over recent decades, impacts on this sensory activity, thus far relied upon. The Internet, as one such new mode of shopping, does not allow for direct sensory evaluation of products. As such, numerous studies have examined the multitude of issues to be considered when the interaction process moves from the physical shopping environment to a virtually represented electronic one, as well as the important issues surrounding the attributes of products when they are sold on-line. Thus, the question arises of how to present sensory attributes of food products on-line and provide an environment in which shoppers can understand, evaluate and experience products, so that the World Wide Web may function as a new tool for food shopping. This is particularly relevant in the case of food products, which lend themselves o be touched, smelt, examined and tasted during the activity of choosing. Additionally, the importance to the process of choosing food, of the social and historical life of the shopper within their own life course has also been argued. Shopping for food can be viewed as an activity which develops over time and is grounded within peoples' experiences. As such, it is an activity, during which, people will consider intrinsic sensory attributes pertaining to the texture, colour, smell, taste, size, shape, weight and sounds of a product, as well as other factors, including price, brand and other information.

In order to explore this activity of choosing food in greater depth, this research has involved the conduction of a series of focus groups. These sessions explored a range of experiences had by people choosing between oranges and apples, based upon their prior knowledge and experience and sensory evaluation. The literature which documents how sensory evaluation of oranges and apples is carried out by people in the physical world, is scarce and the focus groups have therefore been extremely valuable in highlighting the following summary findings. The senses are used unconsciously and automatically during evaluation, choice and consumption of oranges and apples; oranges and apples are evaluated according to standards and parameters of quality and preferences built over time; in the absence of the possibility to assess a particular attribute of the fruit, people use their senses to detect other characteristics of the fruit and infer attributes based on their previous experience and knowledge; associations made over time between attributes can be so consistently maintained as to become stereotypical; the ability to perceive and determine the relevance of attributes is shaped over time and shared and developed between members of a community.

Purposefully, an Activity Theoretical framework has been laid out, in order to help this study in analysing the sensory evaluation of food, by emphasising the experiences of shoppers and the historical and cultural context in which such activities are carried out.

Depending upon the purpose that a shopper may have when setting out to buy apples, be it to buy fruit a for a child's lunch box, apples for a pie, or perhaps to make apple juice, to name some examples, they seek to find the apple that is right for a specific purpose. Whether it is only to satisfy hunger or to buy the latest cross-species variety, mental activities are carried out oriented towards the achievement of objectives. The achievement of such objectives, which should satisfy the motives of the overall activity of buying apples, is reached through intermediate action goals. Recalling the previous discussion on the shopping activity and sensory evaluation of food, it should be stressed that shoppers evaluate the attributes and other information provided about a fruit, when choosing apples to buy. The sensory evaluation activity, is supported by specific tools which people have built throughout their lives and which they continuously change and renew, taking with them experiences of the past. Particularly, psychological tools are brought into play with the support of operations. The choice of an apple, including the visual inspection of it, the touching and manipulation in the hands, the smelling or perhaps tasting of the fruit, are all targeted towards the satisfaction of the buyer's ultimate objective.

Throughout time, people, who in this specific case are considered as consumers, perfect such tools and operationalise particular actions. In circumstances where, not only the sensory evaluation is involved, but other factors, such as the brand, price and mode of purchase are considered during the shopping activity, it is possible to speak of risk reduction strategies. Current and past literature is replete with such terms. Activity Theoretical practitioners might identify these risk reduction strategies as psychological tools which carry with them the experiences of the people who use them, but at the same time should be seen within the context in which they are conceived. Buying fruits in a southern region in Italy, can be an experience that is noticeably different from other social-cultural contexts. Buying a watermelon during the summer season in this context, often involves the seller taking a core sample from the melon for the shopper to inspect before deciding to buy the fruit or not. The individual might seek a guarantee that the melon is of the right quality, observing attributes such as the colour, juiciness, firmness and likely ripeness of the flesh. Such activities may not take place in other cultural contexts. Nonetheless, other tests of a melon's attributes might be observed in both contexts, such as knocking on the exterior of the melon.

Further, what the psychological tools of sensory evaluation of food and risk reduction strategies mentioned within current literature, have in common, are the attributes of a product itself, which are cited more generally in the consumer research literature, as product information. In the case of the former, mental activities through the use of tools, manipulate the reality. In the latter, it is accepted to speak of human information processing. Both consider anyway, the context and the experiences of the consumer as central to either the risk reduction strategies or the development of tools. Briefly summarising the above discussion, it can be said, that people carry out sensory evaluation when buying apples. During this evaluation, a set of unconscious operations, support the action of choosing an apple for a specific goal. The operations relying on the senses, support the action targeted at the product attributes. This is to say that during the evaluation process, people evaluate product attributes to identify those which conform to specific requirements for the achievement of the goal. This is achieved by actions mediated by psychological tools.

Importantly, Activity Theory provides a framework for a deep understanding of the sensory evaluation activity, for the formulation of design guidelines targeted at usability and HCI issues, with particular reference to the World Wide Web. Thus, this study seeks also, through an Activity Theoretical framework, to explore ways of enabling on-line shoppers to evaluate the sensory attributes of products by the use of the two available senses; sight and sound. Namely, images and text are considered as means of presenting attribute information about food products. This is based on the assumption that, appealing to the experiences of people, and the knowledge they have of the attributes of a product, on-line shoppers evaluate the sensory attributes if provided with peculiar characteristics of the attributes of the product. Examples of this can be the picture of the cut of an apple, a close-up of it's skin, or the sound of it being bitten into, which may be recognised by the shopper through past experience, to be clues about the apple's crispness or mealiness. These assumptions are currently under investigation. Navigation of the on-line through the search of sensory attributes, sharing sensory knowledge within the community of on-line shoppers are other relevant issues raised by this research.

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User Adaptive Information Visualization

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Abstract

During the last few years, the number of large volume databases has increased dramatically. Consequently, it is much more difficult to understand the retrieved - often multivariate - information. User-adaptive visualization systems could assist this process. This paper gives an overview of information visualization systems, notably Mackinlay's APT system, and outlines my research aim of adding a user modelling component to an APT-like system.

Introduction

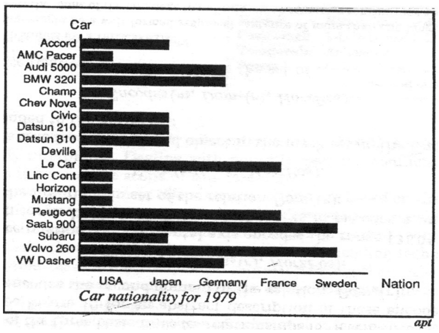
Information visualizations are powerful ways of organizing multivariate data so that it can be better understood. A classic example is Mackinlay's APT system, which auto-generates optimal representations of multivariate data in the form of charts, bars, graphs, or tables. However, these are information-dependent, rather than users' familiarity, preference or cognitive style, which can limit their usefulness for individuals. Hence there is a need for visualization systems not only to take into account information dependency, but also should employ user modelling techniques.

Intelligent display systems

Automatic visualization systems (AVSs) generate graphical visualizations intelligently depending on the particular type of information to be presented. These systems analyse the source data and produce a specific visualization that optimally represents the data. Mackinlay's APT system (Mackinlay (1986)) generates 2D charts, plots and maps that meet strong criteria for effective presentation. The system is fully automatic. The user has only to provide the database query and the system intelligently matches the information to a graphical representation. The importance of the APT system lies in the fact that it includes a graphical representation language which expresses a graphic as sentences in the defined formalism. The graphical representation can therefore be characterized with this representation language. This language has a precise syntax and semantics in the form of a propositional formalism. With the underlying language the system decides which role a particular sign or symbol a graphic has and optimises the form of a graphic using a formal method for mapping relational facts into graphical facts. It includes graphic design issues that are codified as expressive and effective criteria for each graphical language. With this classification the system can make decisions about the inclusion or exclusion of a particular graphical element. Expressive criteria determine whether a language can express the information, based on an analysis of the semantic properties. The criteria use and extend the cognitive psychological work of Cleveland and McGill (1984) to compare the effectiveness of different graphical representation for different types of information. Figure 1 and 2 are examples of APT's output. Both images show the countries of origin of particular types of cars. Figure 1 shows a misleading form of expressiveness. The length of the bars might be encoded as an ordered quantity set, whereas it needs to be encoded as a non-ordered nominal set. Figure 2 shows the correct use of a plot chart. Here it is clear that all the information is encoded and not additional information as in Figure 1.

Mackinlay's APT system uses an information analytic approach and does not take user tasks or a user model into account to produce or design the graphical output. Additional factors which influence the suitability of a graphical representation, such as the task for which the user requires the presentation, have been integrated in the following adaptive visualization systems.

SAGE (Roth, 1990) and Roth (1994)) added to Mackinlay's APT system the idea of information goals to the graphic selection process. Information goals refer to the functionality of the presentation. It combines automatic and user-manipulable design techniques to produce intelligent data visualization.



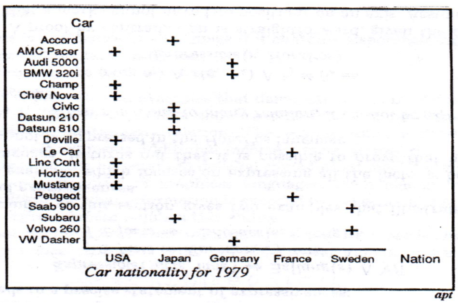


Figure 1 APT: incorrect use of a bar chart

Figure 2 APT: correct use of a plot chart

It takes as input a characterization of the data to be visualized, along with the user's data viewing goals.

Casner (1990) stated that the use of a graphic representation is influenced by the task to which it is applied. BOZ (Casner, 1990)), is a task-analytic approach to the automated design of graphic presentation. This system uses the same data characterizations as Mackinlay's APT. Whereas SAGE uses information goals, BOZ uses task goals. Task goals refer to the user's task for which the display is required. BOZ analyses the logical description of the task, required by the system user, and generates an equivalent perceptual task by substituting perceptual inference steps in place of logical inferences in the task description.

Individualized information visualization

Mackinlay assumes that all humans are similar in their perceptual abilities and in their ability to comprehend the types of graphs and charts APT produced, which might not be true, because of their different familiarity or preferences with particular types of graphical representations (Cox, 1999). As stated in Cox (1999) individuals differ while reasoning about an external representation in terms of their background or prior knowledge of external representations, their preferences in and their degree of externalise their reasoning about external representations. Some external representations can be used efficiently, because of general familiarity or experience with it, while others, like Euler's Circles have to be learned specifically.

Additionally, individuals differ according to their cognitive style. Some individuals prefer to process information visually through graphics or diagrams, while others prefer to process the information verbally (Kirby et al. 1988).

Cox et al. (1994) classified diagrammatic reasoners and non-diagrammatic reasoners depending on their performance on analytical reasoning problems in a diagrammatic type. They used a computer based learning environment in the area of first-order logic, Hyperproof, which includes graphical and syntactic modalities, to demonstrate large individual differences in reasoning on diagrammatic reasoning problems.

Hence, the usefulness of particular information visualizations varies according to individual differences, as described above. This should be taken into account to produce efficient information visualization.

User model

A model of the user which reflects their cognitive style while interpreting an external representation, their familiarity and preferences should be included.

An AVS information display to a user provides ways to build intelligent computer systems that are more efficient for the user. The effectiveness of a graphical display can be enhanced through tailoring the information for a particular user. For example, one person might prefer to find the information which is needed in a textual description, whereas another might prefer a graphical representation. The proposed AVS with user model would decide which type of information equivalent external representation suits the particular user best (for example, textual or graphical representation), based on the user model, and display it.

The information to display should reflect the user’s familiarity with particular external representations, their cognitive style in reasoning with the display, the demands of the task and the semantic properties of the representation.

Conclusion

Developments in intelligent automatic visualization systems have shown that considerable advances have been made over time; beginning with systems which use bar, pie and line charts, through APT that included a composition algebra and primitives to create a wider range of designs, SAGE which extended APT's graphic design issues, to BOZ which included a task-analysis approach.

Information and task goals go some way towards matching representations to tasks and users, but users also differ in terms of individual differences in representational preferences and familiarity with particular types of external representations. Hence, the next phase of intelligent information visualization system research should address adaptivity to individual differences between users. User modelling is one technique to do this. The knowledge about how users make decisions and find a solution for their required task in an external representationd should be included in a user model.

Ideally, a system should accommodate information and task goals and also be adaptive to the user's representation preferences.

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"The use of Lotus Notes and the World Wide Web for knowledge construction: A case study at a Mexican private university"

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Introduction

Information technologies play a central role in university teaching. The use of computers (and the access to other information technologies that computers made possible), is already transforming not only access to knowledge but also its production and transmission. Information technologies constitute a challenge to institutions that need to develop a set of strategies to change several aspects of their organisation and operation.

The use of technologies provides a new role for lecturers. Students are empowered to take responsibility for their learning as they interact with the computer, designing and using their own instructional materials. This places the lecturer in the role of a guide or facilitator, allowing students time to work collaboratively to solve problems. (Peters, 1995)

This paper is concerned with the changes computers have brought to the relations between lecturers and students in universities. It will analyse how lecturers are using computers in the lecture room and the impact of this use in gender. Furthermore, the research will explore the changes the use of the Internet brings to the acquisition of knowledge and the role that students are playing in with the introduction of computers in the lecture room.

Research context and approach

The paper is based on a case study of selected departments/faculties at the ITESM, a Mexican private university with 30 campuses in Mexico and 9 other countries in Latin America. ITESM was founded in 1943 by a group of Mexican entrepreneurs with a clear emphasis on integrating the use of computers in their teaching process since 1997. It is considered to a significant role payer in Mexican higher education in the filed of using ICT in teaching and learning. The ITESM offers a valuable case study of the problems and constraints in using ICT in higher education and human computer interaction.

The ITESM as a university using technologies is innovative as it does not only use one technology at a time (TV, video, computers?) but use multiple technologies simultaneously, covering more than 70,000 students. Furthermore, the ITESM is the only Mexican University massively applying the use of computers into their teaching model. This massive use of computers seeks the interaction between lecturers and learners through a computer mediated learning process where the use of a particular software (Lotus Notes) mediates the face-to-face interaction between learners and lecturers.

This makes ITESM a unique place to research to obtain valuable data regarding the use of ICTs for education purposes. It also raises some questions regarding the way they have been able to develop this experience and the future the introduction of computers will have in higher education.

The use of the software Lotus Notes was introduced with the use of Laptops for all the students at all levels. New entering students are required to buy a Laptop in order to have continuos access to the university Net that may be reached from almost every place within the campus. This is feasible thanks to an internal electronic net that has been installed within the ITESM campus and allows students to access their courses on-line. Furthermore, at the ITESM undergraduate students at their final level, access the course content through an hybrid tele-conferencing-online model. This makes possible an interesting comparison between the face-to-face and the teleconferencing/online models.

This paper will explore the results of data collection at the ITESM campus Guadalajara, Mexico, where students and lecturers were interviewed regarding their use of Lotus Notes and the World wide Web for their undergraduate courses.

Preliminary Findings

In reporting the findings we highlight a fey key themes which have emerged from the data.

Disposition to change

When using technologies for the first time to innovate traditional ways of teaching and learning, lecturers and students have a strong resistance to change. This was pointed out as one of the main difficulties in the process of adapting Lotus Notes as a way of interaction between lecturers and students, in the face-to-face mode. Lecturers felt they had been pushed out of their position in the centre of the lecture room. Students felt they had too much work and had to assume an extremely responsible attitude toward their own learning process. But as students get used to the use of technologies, this resistance diminished. As one student phrased it: "At the beginning there was a lot of opposition towards the use of Lotus Notes. But in reality, when I began using Lotus Notes I think it was much better than I had anticipated" (CL).
For those students at the hybrid teleconferencing-online instruction model, the resistance to change was expressed as a fear of not been able to see the lecturer inside the lecture room. As one student rather angrily commented: "Sometimes we make comments among ourselves but such comments stay in the classroom and will never reach the lecturer" (RH). This fear was emphasized when the distant lecturer does not respond to students' e-mail messages and/or students' questions left on the course website. As one student confessed "Unfortunately, the interaction between lecturers and students is not that good sometimes. We send them an e-mail and they do not reply immediately only after 3 days. I know this is not our fault or their fault if they receive 200 or 300 e-mails daily". (DA)

Changing roles
A major challenge for lecturers and students in both models (the face-to-face and the hybrid mode), was the transformation of their role. One lecturer suggested that it was extremely difficult for him to motivate his students to play a different role within the lecture room, a more active role where they did not come to be lectured but to learn by themselves. This idea was emphasized by another lecturer who said that since the use of computers was an imposition on lecturers and students, they have had no choice but to adjust to it. Most of the interviewed students in both models expressed concern about the amount of work they have to do since the use of computers for instruction was adopted at the ITESM.
Regarding the use of computers for collaborative learning, all of the lecturers and students interviewed sustained that computers promote this kind of learning. Nevertheless, students and lecturers in the face-to-face mode, showed some disagreements about the role of Lotus Notes in promoting this collaboration. Some of the lecturers sustained that it was not the software itself that promoted collaborative learning, but lecturers' application of innovative pedagogic techniques. As one lecturer phrased it: "Ideally, computers promote collaborative work among students but in reality what happens is that when a lecturer assigns work to a team, generally there are always only one or two students who work, and the rest of the team members rely on their colleagues work" (JV).
For those trained lecturers in PBL technique, the application of this pedagogic practice was like the core to promote group discussion and interaction within students. For those less trained lecturers, the fact that students did not get involved in collaborative work was influenced by their young age and their resistance to change as well as their early involvement in higher education since they were just in their first year of their degree.
Collaborative work in the hybrid teleconferencing-online model, was a very controversial topic among students. Students feared the idea of working collaboratively, expressing their need to invest too much time for that kind of interaction with distant colleagues: "I do teamwork in several of my courses and sometimes this is very complicated since I have to get together with six different teams let's say, in one week. So it is really too much work" (DA). But despite of the amount of work, this same student showed enthusiasm when referring to his role in the online course. He underlined his active role when taking part in a teleconferencing-online course: "I definitely feel more active at a virtual lecture because at it each student is responsible for his/her own education". (DA)

Student-centred learning
A major challenge for students in both modes, was computers' promotion of a student-centered approach. Lecturers' and students' expertise in managing Lotus Notes was emphasized as a determinant factor in the promotion of student-centered models inside the lecture room in face-to-face instruction. One of the lecturers show very little knowledge of the use of the platform and therefore her students did not feel the use of Lotus Notes had changed significantly their present role in the

lecture room. On the other hand, lecturers emphasized the different attitudes that students can take when using technologies for learning. Some of them get involved fast and some are very reluctant to any change in their traditional passive role inside the lecture room. As one of the lecturers phrased it "There are still some students who are afraid of not knowing how to use Lotus Notes" (RV).

One of the lecturers employed software simulators inside the lecture room and showed complete agreement with the idea of computers promoting student-centered approaches. He underlined the fact that while using computers the students work in case studies analysis. During the process of analyzing a particular case, they were the producers of the needed theory to solve cases and practical problems: "My students have to answer questions and encourage discussion They have to make interest comments to their classmates" (JAV).

For those students in the teleconferencing-online model, this issue was even more relevant. One of the students expressed with vivacity: "I think this is what I have learnt (from the teleconferencing-online instruction model): to search for information following my own interest" (RH).

Usage of Internet

One of the key topics that was crucial in the transformation of students' and lecturers' role and students' and lecturers' interaction was their use of computers and the Internet. One lecturer in the face-to-face model expressed concern because she and her students did not have enough computer skills to use Lotus Notes. She explained: "We all need to be trained to use computers better" (RV).

For another lecturer in the face-to-face model, the fact that some of his students did not have enough computer skills, was an opportunity to encourage class discussion and interaction with their peers. As he phrased it: "Those students who did not have a lecture with me before are not familiar with the use of the platform. If students don't know how to use Lotus Notes I tell them to approach those classmates who use it or to come to me to solve any problems they may have" (JAV).

Computer skills were a determinant factor within the teleconferencing-online mode. Both lecturers and students in this mode said they spent several hours of the day connected to the Internet, using the course website. One student within the face-to-face mode said with enthusiasm: "I use my Laptop at least more than five hours daily. If I am not using it for working purposes, I use it to listen to music. I have everything inside my Laptop" (EG).

Another student in the teleconferencing-online model expressed: "I use the Internet a lot. I search there for information regarding each task I have to do for the lecture. I have my own Laptop and spend around six hours a day using it. During these, twice a week I visit the course website" (SV).

Conclusions

The research conducted indicated that it is important to accept that a wide range of factors influence success when using computers and the Internet for knowledge production and transmission. The paper presents and analyses some of these factors.

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Session 4

In which ways can models of knowledge inform the design and uses (or tendencies) of Information Technologies?

Learning with Interactive Graphical Representations: assessing the benefits of interactivity through the analysis of learners' video recordings.

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Introduction

Interactive graphical representations have been used and promoted to facilitate learning (Cheng, 1999). However, not much is known about what kinds of graphical representations and what forms of interactivity are effective (Rogers, 1999). The present research explores how external cognition affects learning (Scaife and Rogers, 1996; Rogers and Scaife, 1997). More specifically it addresses the question of whether providing 3D interactive graphical representations in problems that require the depiction of 3D properties is beneficial for the learning process.

In order to address the research question stated above, four Interactive Learning Environments (ILEs) were created with different graphical representations. Each learning environment tackled the same concept in the same manner, except for differences in the diagrams and interactivity. In total, the ILEs were composed of 15 diagrams distributed along six explanatory steps with accompanying text. So, the ILEs are in fact using two different types of representations, graphical and textual, in separate frames. Two 2D systems were built differing in the possibility for learners to manipulate the diagrams' elements. Two 3D systems were also built, again differing in the possibility for learners to manipulate diagrams' elements. The four systems were named 2D, 2DI, 3D and 3DI.

The stereographic projection was chosen as the application domain. It is a one-to-one transformation from the surface of the sphere (the surface of a 3D geometric entity), less one point, onto a plane (by definition a 2D geometric entity). In general terms, the concept belongs to the geometry domain, but in the case of this study there is an emphasis on one of its particular applications: the problem of studying symmetry relationships in crystallography. Some of the graphical representations in textbooks explaining the concept are 2D diagrammatic representations that, through the use of pictorial cues are intended to show 3D "objects" (see, for example, Borchardt-Ott, 1995). The issue here is whether these representations are more easily understood when 3D interactive diagrams are employed, considering that students usually have some difficulties learning the concept and manipulating the resulting 2D final representations, the stereograms.

Eighty subjects, 42 first year undergraduates studying a geology course and 38 from a mathematics course, were randomly assigned to one of the four ILEs. The experiment comprised three different moments:

- Moment 1 - Prior to the use of the ILEs, the subjects were tested on their spatial ability through the Paper Folding Test (PFT) (Ekstrom, French and Harman, 1979) and their geometry knowledge through a geometry test (GT) similar to the GRE geometry module.
- Moment 2 - The subjects were instructed to explore the geometry concept with the ILE they were allocated to and answer the questions displayed at the end of each text frame (**the multiple-choice test- MCT**). A brief explanation of the functionality of the different ILEs was also given. No constraints were imposed on the time available or sequencing of the exploration.
- Moment 3 - Finally, a **post-test (PT)** was completed that consisted of 17 questions about the concept taught.

The initial results report to the analysis of the learners' scores in the multiple-choice test and its relationship with spatial ability and prior geometry knowledge (for a more in-depth description of the analysis see Otero, Rogers and du Boulay, 2001). The major findings were:

- We did not find an overall best ILE; the scores in the multiple-choice test did not differentiate significantly by type of ILE.
- Subjects with different levels of spatial and background knowledge (coming from the geology or maths degree) seem to benefit more from different types of ILEs, which somehow supports Cox's (1999) affirmation that the successful use of an external representation is dependent "…upon a complex interaction between (a) the properties of the representation, (b) the demands of the task and (c) within-subjects factors such as prior knowledge and cognitive style." (p. 343-344).

However, in order to have a better grasp of the possible causes of the referred results, a video analysis of the learners' interactions with the ILEs was performed.

The video analysis

The video analysis inscribes in a more qualitative data analysis stage. Eighteen subjects were chosen from a sample of 40 videoed subjects. The main goal is to find behaviour patterns that clarify the results obtained in the quantitative analysis. It comprises two types of coding done in parallel, with the corresponding outputs:

- One type of coding involves active interpretation of user's actions making assumptions about the meanings of what is being observed. It is called Interpretative Coding (IC). The main goal is to uncover the pattern of learner's switching between the textual and the graphical representations. Thus, I intend to display the learner's flow of activity, or rather, my interpretation of the flow of activity.
- In the other type of coding only the unambiguous visible activity that the user is displaying is registered. This implies not making assumptions about the meanings or functions of actions or sequence of actions. This coding is named Action Recording (AC). In this case the output of such coding is a stream of actions.

The two types of coding were inscribed in a specific diagram to facilitate the identification of the behavioural patterns. The construction of this diagrammatic representation was done for each learner and involved two steps:

- In the first step I wrote the coding relative to the AC.
- The second step relates to the registering of the IC coding. This second phase benefits from the fact that the AC is already displayed, and allowed the re-interpretation and re-coding whenever was needed, according to possible emerging patterns not devised in the initial coding (step one).

After building the diagrammatic representation it is necessary to write up a story that tells us:

- How each learner interacted with the ILE.
- How does the interaction pattern might have influenced the performance in the MCT and PT.
- How learner's background knowledge and spatial ability can relate to the patterns uncovered.

Below are the basic general questions that frame the overall analysis of the coding done that will enhance the comparisons between subjects:

- How long did the learner spent in exploring the ILE?
- How long did the learner spent on each explanatory step? How is the score of the multiple-choice test (MCT) obtained in each step related to the time spent interacting?
- How long did the learner spend exploring the ILE before reaching the questions part?

- Are there any differences in type and number of actions between the period of "reading" the information and answering the questions?
- Are there any differences between subjects concerning the number and sequence of transitions between different areas of the ILE (areas are considered to be the textual part, the questions, or the diagrams)? What about type and number of actions in each transition?

The questions presented above helped us to form a story of each learner ILE exploration. However, the comparison between subjects (in our case 18) seems to be difficult if we start comparing all the subjects based on each individual story: too much detail can hide important aspects. An alternative is to try to condense the information gathered by using caricatures that capture the essential of an interaction pattern. The plan, then, is to find a caricature for each question presented above, classifying the subjects as if the caricature was a dimension and rank the subjects accordingly. The next step could be to form, say, 3 groups based on the rankings and see how each subject inscribes in the several caricatures. In the end we will have a description of each learner composed by his positioning in the caricatures/dimensions and additional descriptive snippets of interaction that elucidate and reinforce the overall pattern.

The initial results of this analysis will be presented at the workshop.

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FROM ETHNOGRAPHY TO ARTIFACTS: A DESIGN METHODOLOGY FOR DEVELOPING NEW TECHNOLOGIES FOR THE DOMESTIC ENVIRONMENT, WITH PARTICULAR REFERENCE TO BROADBAND AND 'ALWAYS-ON' SERVICES

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Introduction

This paper details the development of a design methodology for creating new technological artifacts for the domestic environment that harness the potential affordances of broadband technology in order to create 'always-on' services. With reference to one possible new broadband service, the 'always-on multimedia calendar', a prototype application will form the basis for field trials that will inform the key usability issues for designing such artifacts and the socio-cognitive implications of being 'always-on' in the home.

Prior Research

O'Brien, Rodden, Rouncefield and Hughes [1] undertook an ethnographic study of a number of homes in order to, 'highlight key aspects of the social dimensions of households relevant to the potential uses of new domestic technologies'. Their findings with regard to the social organisation of the home were used as a focused framework for an in-depth field study undertaken to compare the Internet usage of twelve households with broadband access. With respect to the social implications of this new technology within the home, the study examined Internet usage trends and how these may have developed and/or changed now those households have 'always on' capabilities rather than dial-up access. This was determined by conducting semi-structured interviews in order to define how the technology had been adopted into the social organisation of the household environment based on four parameters as expounded by O'Brien et al. The main findings concluded that households with broadband Internet access spent significantly more time online and visited more sites than when they had regular dial-up access. The two main benefits of ADSL/broadband, as perceived by participants, were the permanent connection and speed. Other perceived benefits included the fixed fee, freedom to use the telephone line and, even, a social concern regarding the benefits of working from home.

Main Findings

- Participants were spending more time online searching for information to the detriment of other sources i.e. books.
- Participants were using the Internet more to work from home.
- In terms of sending and receiving Emails that was no specific evidence that this had increased but participants were aware of the value, and highlight one of the properties, of being always on in that they could check Emails when they wanted i.e. every 15 minutes if they so desired.
- In terms of eCommerce, there again is some evidence that participants with ADSL are spending more money online or at least it enables them to research products in order to get the most competitive price.

- Due to the quicker download times participants were more willing to upgrade software online.
- Entertainment such as online gaming was also a popular pastime for participants.
- In most households the PC had a separate room or space dedicated to its use but there was a definite feeling that a particular person 'owned' the technology and therefore had priority of use.
- All households stated that every member had access when required but one person within the house usually had some sort of priority. At this point households usually developed some sort of routine to offer access to each member when required.
- Where space allowed, most people preferred some sort of office environment where they could separate themselves and the technology from the rest of the household. This was done for two reasons and gives an insight into the status attributed to the technology. Firstly, the technology was usually used for and/or associated with work and therefore was a very important artifact and therefore, required an attributed and dedicated 'workspace' of some kind. However, this special 'workspace' was also created so the technology did not impinge on more social spaces within the home such as the lounge or main living area where non-work activities would take place. This was so important that some households had placed the PC in the main bedroom rather than have it in the lounge.
- When asked the question as to whether participants did actually have the computer 'always-on' they responded in a way that suggests, 'access when we want it' would be a more constructive metaphor.
- From the interviews it also became apparent that the computer has limited functionality and there is still a need for other interaction and communication devices.

Personal Information Management

'Personal information management' [2] is the phrase coined to describe that myriad of data necessary to manage our daily lives, complete all those mundane but necessary day-to-day tasks and generally maintain the *status quo*. It may take the form of addresses, phone numbers, to-do's, appointments, notes, documents, folders, u.r.l.'s, Email addresses etc. The source of such information may also be found in a variety of forms including books, letters, diaries, calendars, bills, videos, photographs, telephone directories etc. - the list is endless. Obviously, within the domestic environment a mine of information is necessary in order to augment specific household tasks (whatever they might be from recreation and entertainment to cooking to paying bills to bringing up baby) and that are either undertaken either in the home in general, by particular family members and/or each specific room or dedicated space within that environment. Below, I just wish to consider a very limited number of the information sources within the home and consider some form of broadband/'always-on' application that synthesises and thus, enhances individual artifacts to provide new and dynamic functionality.

Within the domestic environment there are a number of artifacts used to mark major family events and milestones as well as aid with time management and utilisation. For instance, the photo album or 'home video' collection is a pictorial record of major events (weddings, birthdays and/or other milestones), the diary is more of a personal and therefore private artifact to help organise personal priorities (such as work, leisure and family time) as well as time allocation or for personal thoughts ('Dear Diary…'). Within the home there will also be some sort of shared artifact such as a calendar or possibly even a dedicated 'notice' area (i.e. refrigerator door or pinboard) which will be used for communicating details of a shared activity, event or other relevant information (i.e. important extended family birthdays), as well as other personal activities that may impinge on mutual time [3]. This would seem an ideal situation to develop some sort of device or service harnessing the affordances and properties of broadband technologies in order to aid member communication within the domestic environment. What I'm proposing is some form of virtual artifact (a calendar for want of a better word) that forms a virtual multimedia record of the past that can be shared and celebrated amongst family members as well as a means of organising the future and aiding communication.

The 'Always-On' Multimedia Calendar

What I'm proposing is to develop a prototype system, the "'Always-On' Multimedia Calendar", that has the properties of a regular calendar (Temporal Orientation, Scheduling etc. [4]) but is not simply an electronic version of a paper-based artifact as the affordances of broadband technology offer so much more than that. As well as the functionality of an online calendar the 'multimedia' version could form an archive and living record of family events and milestones that could be shared amongst immediate and extended family members wherever they might be as well as an online community, if so desired. As stated earlier, such information may include photos, notes, personal favourites, video clips, sound files, children's work and drawings - the choice is endless. The properties of broadband technology also allow the transfer of information across devices as well as new and novel display, visualisation and input devices (all of which will have to be determined as part of developing a prototype). In order to develop user requirements for such a system I think it is necessary to undertake an in-depth study of calendar use within the home as well as some of the information archives I have already mentioned.

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Multimedia and multimodal systems: commonalities and differences

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1. Introduction

This paper focuses on the differences between multimodal and multimedia systems as well as some assumptions of multimodal interaction. It is argued that effectiveness of human-computer interaction can be maximised when the interactive experience is unified.

2. Definitions

Due to differences on terminology usage in the literature the terms modality, medium and representation need to be defined. In a communication act, such as learning in a classroom, modality refers to the sensory or perceptual experience (e.g. visual, tactile, etc.) and is closely related to the individual. Medium is a means of conveying a representation (to a human), e.g. a diagram or a text. Representation sketches or stores information, e.g. semantic net, English language. Consider, for example, a classroom where pupils are taught about gravity. They listen and look while the teacher explains by speaking and gesturing (perceptual experience). The teacher has written an equation of gravity (w=m*g) on the board as well as a diagram. These are different types of representation. Some of the artefacts that the teacher or the pupils use carry several representations, e.g. the board contains text, form or diagram written on it. Imagine now that pupils use the pen as an artefact to experiment with the law of gravity. Modality refers to the use of visual, auditory or tactile cues that pupils use to see the representations, hear the teacher's presentation or handle the pen to understand by doing (sensory or perceptual experience).

Additionally, the concept of multimodality needs also to be introduced. Multimodality is based on the use of sensory modalities by which humans receive information. These modalities could be tactile, visual, auditory, etc. It also requests the use of at least two response modalities to present information (e.g. verbal, manual activity) (Baber 2001). So, for example, in a multimodal interaction a user may receive information by vision and sound and respond by voice and touch. Multimodality could be compared with 'unimodality', which would be based on the use of one modality only to receive or present information (e.g. watching a multimedia presentation and responding by pressing keys).

3. Interactive systems

Multiple representations or multimedia systems share a common aim with multimodal systems: the effective interaction with the user. Effective interaction is considered regarding a system that is not only easy-to-use but also able to support the user in performing a task. Independently of the technological differences in the implementation of those systems, they aim to support their users while they perform particular tasks.

However, multimedia and multimodal systems have important differences. Lee (1996) identified that multimedia systems deal with the presentation of information. Multimodal systems interpret and regenerate information presented in different media (Lee 1996). Turk (2000) transfers the comparison to the user interface. According to him, the distinction between multimedia and multimodal user interfaces is based on the system's input and output capabilities. Thus, a multimodal user interface supports multiple computer input and output, e.g. using speech together with pen-based gestures. A multimedia user interface supports multiple outputs only, e.g. text with audio or tactile information provided to the user. As a result, multimedia research is a subset of multimodal research (Turk 2000). Baber (2001) argues that multimodal human-computer interaction can have two perspectives: the human-centred and the technology-centred. According to the human-centred perspective, multimodal systems should support more than one sensory and response modality of the users. The technology-centred approach defines a multimodal system to be one that supports concurrent combination of (input) modes. Alternatively, it could at least specify which mode is operational on each situation (Baber 2001).

An alternative difference between multimodal and multimedia systems can be based on the perspective of the interactive experience. From the system's point of view, a multimedia system is also multimodal because it provides, via different media, the user with multimodal output, i.e. audio and visual information, and multimodal input, e.g. typing with the keyboard, clicking the mouse. From the user's point of view, a multimedia system makes users receive multimodal information. However, they can respond by using specific media, e.g. keyboard and mouse, which are not adaptable to different users or contexts of use. Additionally, while interacting with a multimodal system, users receive multimodal input and are able to respond by using those modalities which provide convenient means of interaction. While in multimedia systems the user has to adapt to the system's perceptual capabilities, in multimodal systems the system adapts to the preferences and needs of the user.

This argument, however, aims to highlight the importance of the interactive experience and not the importance of the individual per se. If the distinction is based only on the individual, a system could be multimodal for one user and multimedia to another.

3.1 Assumptions in multimodal interaction

In multimodal systems research, it is often assumed that human-human communication is 'maximally multimodal and multimedia' (Bunt 1998). The 'added-value' of multimodal systems is taken for granted and there is a lack of research about *why* we need to develop them. As Bunt (1998) stated: "in natural communication, all the modalities and media that are available in the communicative situation, are used by participants" (p. 3). But this is not always the case.

Furthermore, current research on multimodal interfaces is based on the naturalness of communication between the user and the system (Marsic 2000). Naturalness refers to a human-computer communication that would be like human-human communication. Thus, researchers are focused on technological achievement by generating recognition techniques of natural language, gestures, etc (Waibel 1995; Cohen 1997; Julia 1998; Oviatt 2000). Current research is mainly focused on the integration and synchronisation of different modalities to enhance communication (Bellik 1997; Oviatt 1997b). The main aim is to provide users with a system that is able to emulate how humans interact with each other. It would take advantage of human and machine sensing and perceiving capabilities to present information and context in meaningful and natural ways (Turk 2000).

However, there are differences between human-human and human-computer interaction. In human-human interaction, for example, there is available a quite sophisticated system (human's mind), which indicates which modality to be used and when. Current multimodal research often assumes that technology supported modalities are useful while performing particular tasks without questioning why.

Additionally, while humans interact with the computer, they need to transform their conceptions of activities into systematic and procedural functions. When the interaction is completed, humans need to interpret the interaction in order to make sense of it. For example, to transform feet into centimetres with a calculator, users need to think of procedures to figure out what calculations they need to do. When the calculation is completed, they need to interpret the result to make it useful, e.g. imagine the result in length.

While interacting with the calculator, humans need to know much more than how to use the calculator. They need to know how to transform feet into inches, what is the relation between inches and centimetres, etc. The procedures, however, have been internalised and are considered as one (Collins 1990). The experience has been unified and it is perceived as a whole. Another example of a unified experience would be how to drive a car. At the beginning, drivers need to think each procedure, e.g. to change the gear. As they gain expertise, the task become internalised and unified. Drivers then can do other things while driving a car, e.g. discuss.

To summarise, to what extent multimodal systems research should focus on supporting natural interaction as opposed to *effective* interaction is under question; where effective interaction is defined in relation to some task, e.g. the learning outcome (Lee 1996). A successful interaction with a multimodal system would be one that provides the user with procedures unified into an integrated experience. In the case of educational technology, a successful multimodal interaction would be one where users could overcome the difficulties they have while interacting with technology and are able to concentrate on the content of the information provided. In such an occasion the technology would fulfil its main aim to become the artefact that provides information/knowledge to the user. From the users' perspective, users could unify their experience of interacting with technology into an integrated one that would focus on learning.

4. Conclusions

This paper is focusing on differences between multimodal and multimedia systems. Multimedia systems refer to users' adaptation of a system's perceptual capabilities. Multimodal systems support users multiple ways of response according to their preferences and needs. Furthermore, assumptions of multimodal interaction are discussed to reveal shortcomings of current research. Initially the 'maximum' use of multimedia and multimodal communication is discussed, to expose the concept of the 'added-value' of technology. Subsequently, the concept of naturalness of communication is compared with the concept of the unified experience. It is argued that an experience that can be unified with expertise would lead to more effective human-computer interaction.

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User discourse and technology design

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Abstract

My research explores techniques adopted to capture and analyse the language employed by technology users and that within interfaces. It draws upon methodologies from social psychology and the field of human-computer interaction. Borrowing such techniques from more traditional discourse analysis it is possible to interpret the language of the user and better inform design. It has the potential to capture and utilise the words and phrases spoken and written by people, and ensure that designs reflect this appropriately. Examples of this in action could possibly be the choice of words within menus or within on-screen text boxes such as error messages.

Introduction

Heuristic: Match between the system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order. (Nielsen 1994).

The above is taken from Nielsen's ten heuristics used to evaluate a system's design and usability. This evaluation technique is the most popular of usability inspection methods. The aim of this evaluation is to find the usability problems in the design so that they can be attended to as part of an iterative design process. However there has been very little work on how to discover exactly what this language is and how it can be analysed.

Studies that have gathered user language often lack explanation of the analytic methods used, and how their interpretations feed the iterative design process. A viable framework is needed that can help designers understand their user and user context and therefore aid the design process. Such a method could be used during ethnographic studies, or indeed be another feature of the conceptual design tool box.

This research is concerned with utilising the language employed by technology users in order to inform the design process of future products. I shall present what I have carried out in order to translate the language of the users and their context in order to inform design. This research concentrates on observing users interacting with networked technologies (primarily Email and Web applications) and demonstrates how the use of language can either help or hinder the user in their interactions.

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