PICTIOL: a case study in participatory design

Conference Paper · January 2006

DOI: 10.1145/1228175.1228209 · Source: DBLP

Vivienne Farrell
Swinburne University of Technology

Kon Mouzakis
Swinburne University of Technology

Chris J Pilgrim
Swinburne University of Technology

PICTIOL: A case study in participatory design

Vivienne Farrell, Graham Farrell, Kon Mouzakis, Chris Pilgrim, Pauline Byrt
Usability Innovation Group
Swinburne University
Melbourne, Australia
{vfarrell, gfarrell, kmouzakis, cpilgrim, pbyrt}@swin.edu.au

ABSTRACT
Participatory design is an essential element of the skill set of professional interface developers and therefore is a significant component of HCI courses at universities. The PICTIVE technique is a 'low-fidelity' collaborative design technique that encourages participatory design. Significant challenges arise when attempting to introduce participatory design techniques such as PICTIVE to students who may not be studying on campus.

This paper is a case-study in the design, evolution and refinement of an educational software tool designed to provide off-campus students with experience in collaborative user-centred software design.

This paper investigates the origins and value of participatory design and its implementation using the PICTIVE technique. The paper describes the process of creating PICTIOL, a web-delivered solution to provide experience in problem-based learning, emulating the PICTIVE technique. Stages in development of the new software are described, including various HCI testing techniques and the iterative design/implementation/ feedback loop. The paper concludes with a discussion of the potential of the PICTIOL in education and industry.

Whilst the focus of the project was on the development of the PICTIOL tool, the very process of creating PICTIOL is itself an example of collaborative user-centred software design.

Author Keywords
PICTIVE, Problem-based learning, collaborative online learning, CSCW, participatory design, graphical user interface.

ACM Classification Keywords
H.5.3 Information Interfaces and Presentation (e.g., HCI): Group and Organization Interfaces: Collaborative computing; Computer-supported cooperative work.

INTRODUCTION
Participatory design is regarded as an essential component of Human Computer Interaction (HCI) courses at Swinburne University, Melbourne. On-campus students gain experience in participatory design by collaborating on design projects in small groups working face-to-face, simultaneously, on a software design project. There are significant challenges in providing a similar experience for off-campus, distance education students or part-time students who find it difficult to physically meet with other students.

The need for a technological solution to this problem was triggered during the implementation of a flexible delivery Graduate Diploma program which found students living in Melbourne working together with students resident in remote situations including rural Victoria, interstate and international locations including New York, London, Tokyo, Turkey and Singapore. Although the majority of the students lived in Melbourne, they also enjoyed and appreciated the flexible delivery option. The requirement that all students have an equal and beneficial experience of collaborative design provided the motivation to explore how technology could support groups working in multiple locations using participatory design processes.

This paper describes the process of designing and developing software which enables such students to gain experience in participatory design. The paper begins by summarising the origins and value of participatory design and the PICTIVE technique. The difficulties of applying the PICTIVE technique to off-campus students is discussed, and a review of a number of software support tools that support participatory design is presented. The paper then describes the process of creating new web-based software designed to provide off-campus students with experience in the PICTIVE technique. Stages in development of the new software, its testing and issues which arose during the design process are described. The paper concludes with a discussion of the potential of the software in education and industry.

BACKGROUND

Participatory design
The participatory design methodology grew out of the 'Scandinavian approach' which emerged from collaboration between industry and trade unions in the 60's and 70's. Action Research and Sociotechnical Design also contributed to the participatory design methodology (Trigg, 1995, Floyd et al., 1989). More recently, the 'Computer Professionals for Social Responsibility' (CPSR), a 'global organization promoting the responsible use of computer technology' has played an important role in fostering participatory design in the US, largely by sponsoring biennial Participatory Design conferences since 1990. Whilst early participatory design has focused on workplace democracy, trade unions and co-determination laws, its use has now extended into many areas of industry as well as to user-centered design

OZCHI 2006, November 20-24, 2006, Sydney, Australia.

OZCHI 2006 Proceedings ISBN: 1-59593-545-2

practice where the use of prototyping and technology mockups are extensively relied on.

Participatory design is defined as 'an approach to the assessment, design, and development of technological and organizational systems that places a premium on the active involvement of workplace practitioners (usually potential or current users of the system) in design and decision-making processes.' (Trigg and Clement, 2000).

Trigg and Clement (2000) published a list of generally accepted guidelines of participatory design methodology, a summary of which follows. Participatory design involves:

- respect for the users of technology, regardless of their status in the workplace. Every participant is regarded as an expert whose voice needs to be heard;
- recognition of workers as a major source of innovation. Design ideas arise in collaboration with diverse participants although technology is not the only solution to a problem;
- viewing systems as networks of people, practices, and technology embedded in a particular organizational context;
- spending time in the workplace in order to understand an organizational setting;
- listening to people directly affected by problems in the workplace;
- finding a variety of practical ways of improving workers' lives by, for example, reducing the tedium associated with work tasks.

The PICTIVE technique

PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) is a 'paper and pencil' participatory design technique designed for use in the initial stages of creating or updating a computer system (Muller, 1991, Muller et al., 1991). Developed at the Bell Communications Laboratory (Bellcore), it is intended for use in the workplace as a collaborative design technique. All stakeholders are considered to be equal partners in the design process with the goal of engaging management and users, as well as designers and developers, at an early stage in the process. The process centres around the development of a low fidelity mock-up of the system using pen and paper methods. The mockup is intended to be extensively modified in a meeting of all stakeholders. Before meeting, each participant is asked to complete a preparation assignment based on their role in the project and later to share their perspectives on the problem. The meeting is facilitated to ensure a collaborative design process. All design decisions and the rationale behind each decision is usually recorded using video or other techniques.

The great value of the PICTIVE technique is that all participants feel able to contribute on an equal footing (Muller, 1992). It creates a setting in which they are not intimidated by the technology, the terminology or their position within the organisation. Any disadvantage resulting from a lack of expertise or experience in computing is minimised. This is facilitated by using equipment which includes simple office supplies such as paper, pencils, coloured pens, sticky notes and cards. In this familiar and non-threatening situation, individuals with different levels of computer skills can engage effectively in the design process. The paper prototyping technique has proved to be useful, not only for designing graphical user interfaces, but also for more complex multimodal applications (Chandler et al., 2002).

PICTIVE is therefore an implementation of a 'user-centred' approach which embodies the three principles leading to a 'useful and easy to use computer system', namely early focus on users and tasks, observation and measurement of user responses and iteration (Gould and Lewis, 1985). Figure 1 shows the result of a typical PICTIVE collaborative design session. Note the informal nature of the design which at the same time provides a clear message for the software engineer with respect to both screen design and function.

Figure 1. An example of a PICTIVE design space.

Problem-based learning

Extension of the PICTIVE technique to the tertiary education setting meshes smoothly with Project-Based Learning methodology. Goals of project-based learning involve equipping students for their future roles in society by engaging them in solving ill-structured problems that reflect the outside world. These learning approaches take students beyond the accumulation of knowledge and rules to 'the development of flexible, cognitive strategies that help [them to] analyze unanticipated, ill-structured situations [and] to produce meaningful solutions' (Jones, 1996). Tackling an authentic task is, therefore, an important criterion for successful problem-based learning. In practice, problem-based learning is usually conducted with students working in small groups. Students are expected to learn to function effectively as an active participant within a small group and develop the ability to relate to, and show concern for, the other individuals in the group (Pross, 2002).

The realities of modern universities which serve a mix of on-campus and off-campus students has resulted in challenges in providing problem-based learning experiences, particularly experiences that require collaborative work. The provision of a way for off-campus students to work in collaborative design groups provided the impetus for the PICTIOL project described in this paper.

Software Support for PICTIVE

A variety of commercial and research-based software systems exist that provide various levels of support for PICTIVE based participatory design.

SILK (Sketching Interfaces Like Krazy) is an interactive sketching application designed to be used in the early stages of interface design. It was created because current interactive user interface design tools were 'often more of a hindrance than a benefit' in the early stages of design (Landay and Myers, 1995). SILK provides an informal design space on which a designer can quickly sketch an interface using a stylus and electronic pad with the same freedom as on a paper. SILK automatically encodes selected widgets (e.g. scroll bars, buttons and pull-down menus) allowing the designer to test individual components as they are introduced to the interface. Landay and Myers 'envision a future in which most of the interface code will be generated … using tools like SILK'. The DENIM Project is an extension of SILK (Newman et al., 2003). Both SILK and DENIM are informal design tools, elegant in concept and designed primarily for professionals. The hardware and software requirements, as well as the time required to become familiar with their operation, place considerable constraints on the use of such applications by off-campus students in educational settings.

TelePICTIVE is a development of the PICTIVE technique with aims closely aligned with those of the PICTIOL project. TelePICTIVE was designed to facilitate participatory design, including situations in which the designers have diverse levels of expertise and are at remote locations (Miller et al., 1992). TelePICTIVE was designed for the workplace rather than an educational setting. The interface has many desirable features and incorporates the functionality to take the design through to prototype implementation. The interface has a very 'professional' feel and could possibly intimidate naïve or new users, such as students, and may exclude them from making an effective contribution to the design process.

Another technique for addressing the problem of effective remote collaboration is the Distributed Designers' Outpost (Everitt et al., 2003). This system combines low-fidelity equipment such as paper, sticky notes and a whiteboard with number of video cameras and a projector. The Distributed Designers' Outpost requires a considerable outlay of equipment and technical expertise and would not be suitable to support off-campus students.

THE PICTIOL PROJECT

PICTIOL is a web-based software implementation of a PICTIVE 'equal opportunity' interactive design surface. It provides a facility for students to work in groups off campus. Its essential components are synchronous collaboration, immediate verbal feedback, simple non-threatening design components and an appreciation of the role all stakeholders have in the final product. PICTIOL also incorporates basic principles of collaborative group work, e.g. protocols of negotiation, taking turns and feedback when contributing to either the design or the flow of ideas. Each stage in the design process can be saved for later retrieval and analysis and so replaces the need for video evidence as used in the PICTIVE technique.

An example of a PICTIOL screen in its most recent form is shown in Figure 2.

A PICTIOL screen mimics a PICTIVE scenario. Yellow 'sticky' notes, red buttons, lines, ovals and rectangles are available to be dragged and dropped onto the design area. Text can be connected to any item on the design area. Only one stage of the design can be viewed at a time and each design can be saved and reviewed later.

When a design session is set up, participants log in at the same time as one of up to 4 team members: manager, designer, technician or end-user (primary, secondary or tertiary). Although each participant is logged on to the website from a different location, each sees an identical design space at commencement of the session. Only one participant can work on the design at a time, and during that time the other participants are locked out. Each participant's work is colour coded, i.e. a different colour is allocated to each participant. Other participants see each contribution as soon as it has been saved by the author.

Collaboration between participants is enabled in two ways, the Group Panel and the Discussion Room. The Group Panel has three components, two avatars and an area of text. The text indicates which participants are logged in to the design space. It makes clear which participant is in control of the design area at any time and which participants are observing (Figures 2 & 3). An observer can request to make a contribution to the design area at any time by selecting the 'request for a turn' avatar, which waves its hand in response (Figure 3). The current controller, seeing the waving hand, can then choose to relinquish control by pressing the 'Take/Lose Control' avatar.

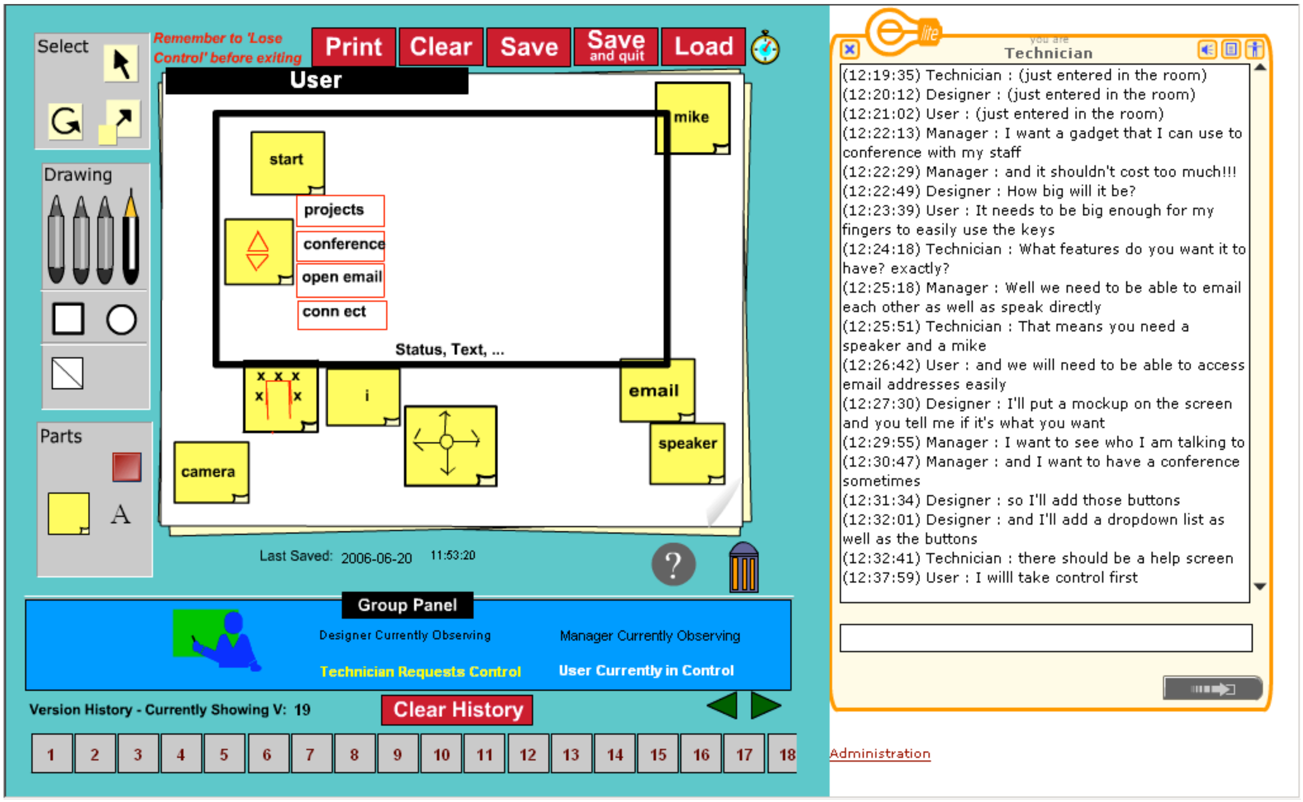

Figure 2. Final version of the PICTIOL prototype. The user is in control, the technician is requesting control.

This action allows an observer to take over the design area by pressing the ‘Take/Lose Control’ avatar, which turns from white to green to indicate control is granted.

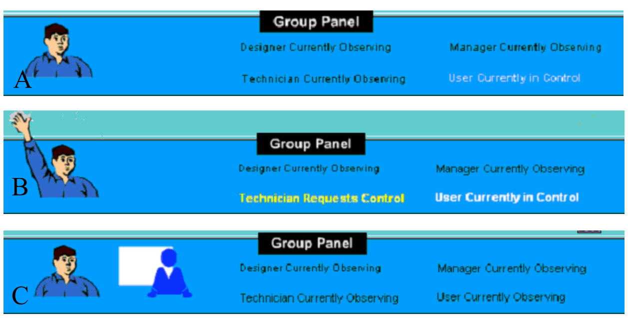

Figure 3. Group Panel from the Technician’s viewpoint. A. The user is in control. B. Technician request control. C. User relinquishes control allowing Technician to take control by selecting the white ‘Take/Lose Control’ icon.

On the PICTIOL screen at all times, by the side of the design area is a text-based Discussion Room. This facility is based on e-lite chat, a real time PHP chat program. The Discussion Room enables all participants in the design process, including both the person in control of the design area as well as the observers, to communicate in real time. All can make constructive suggestions to the design and to respond to criticism. The Discussion Room enables both synchronous and asynchronous communication between participants and all contributions are retained as part of the record of the design process.

A ‘roll-back feature’ enables each participant to return to a previously added contribution and amend/delete it as necessary after negotiation with the others in the group. Participants can only amend/delete their own contributions, but not those of others in the team.

PICTIOL embodies principles of good HCI design (Nielsen et al., 1992, Nielsen, 1994). The status of the system is always visible via information in the Group Panel. The function of each button is self evident. Comprehensive help is available by selecting the ‘?’ icon. Help screens ‘About’, ‘Communication’ and ‘Drawing’ provide concise and clear instructions. Immediate feedback indicating that a requested action has been carried out is provided to users in several ways. For example, the waste disposal bin opens its lid and swells when an object is discarded into it. The ‘turn-taking’ avatar waves a hand and text changes are highlighted by a colour change when an observer requests control and/or takes control of the workspace.

The software was created and tested in several stages. Testing in the first four stages was conducted by a cognitive walkthrough. This technique was selected as ‘valuable for evaluating learnability of the integration of features when those features are at various stages of development’ (Wharton et al., 1994, Spencer, 2000). A cognitive walkthrough provides valuable feedback while avoiding the overhead of a full laboratory usability test. Participants were briefed on the purpose of the walkthrough and given a task to perform. Observers evaluated whether the participants knew what to do to perform the task, whether the system provided guidance as to how to perform the task and if the participant did the right thing, whether they obtained feedback that they were making progress towards their goal.

There were five distinct stages of development of the PICTIOL system each involving several 'design/implementation/test' iterations.

Stage 1. Figure 4 shows the first step in the design of the PICTIOL graphic interface. At this stage it was essentially a single-user computerised version of PICTIVE, designed to implement its essential features. It was created by collaboration between the HCI course lecturer and the software developer. It was designed to enable its user to carry out a design task by drawing shapes (either freehand or pre-defined) and by dragging buttons and sticky notes on to the workspace. Text could be attached to any of the objects and an eraser and a waste disposal bin were provided. The Clear [design space], Log Off and Print buttons were active. The lecturer tested the software at this stage by a cognitive walk-through. Then the software was released to HCI students who were given a software design assignment to complete using it. The students' final designs were submitted for assessment as hard copy.

Feedback from students indicated that they found the freehand drawing tool difficult to use and of limited value. In response to their requests, the freehand drawing tool was replaced with a tool for drawing straight lines.

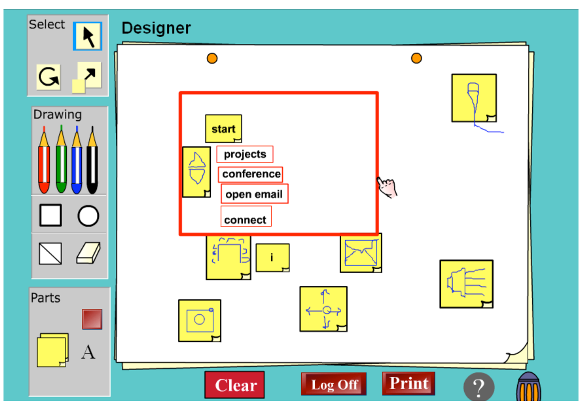

Figure 4. PICTIOL design, stage 1.

Synchronous collaboration between students working on the same design was impossible at this stage. The importance of a 'learning community' for motivation and achievement of off-campus students was soon recognized by both staff and students and this underlies the changes made in Stage 2.

Stage 2. PICTIOL was developed for online utilising PHP[1]. This stage provided the ability for up to 4 students to participate at any one time with each assigned a separate role in the team. This stage was tested by a chauffeur-driven cognitive walkthrough with experienced HCI academics. Participants in the walkthrough were located in adjacent rooms to facilitate immediate feedback with each other, the designer and the software developer. A major problem was quickly recognised because participants found that they needed to shout to each other to get their turn at screen design.

A turn-taking protocol was therefore incorporated into the software. A Group Panel was created with functional turn-taking avatars available to those participants not currently working on the design area (described above, see Figure 3). Communication protocols are important in all group activities but they require particular attention in situations involving computer-supported collaborative work (CSCW) such as the PICTIOL project. Protocols are important for effective social interaction between the participants requiring direct verbal communication. Protocols are also required for the range of technical issues associated with efficient software performance. As the PICTIOL project progressed, the need for an effective flow control mechanism with appropriate protocols established for turn taking and feedback became evident. PICTIOL was designed therefore, to enable synchronous online group participation. It is an example of 'tightly-coupled' collaboration between participants who need to coordinate their actions constantly in real time (Liu and Sycara).

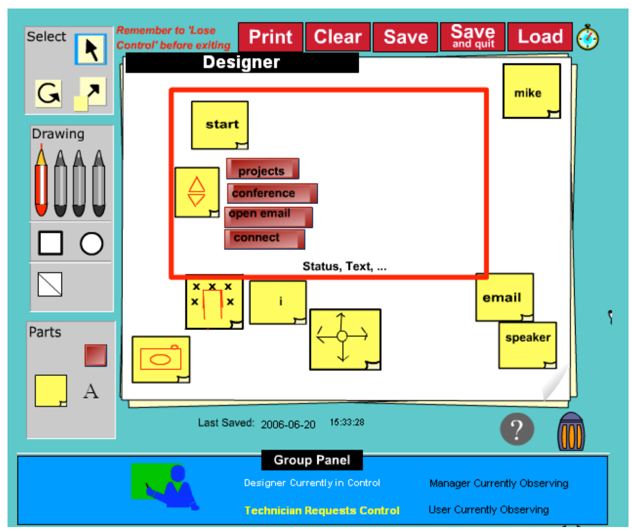

Figure 5. PICTIOL design, stage 2.

At this stage another cognitive walkthrough was conducted with HCI experts. The walkthrough was conducted with participants in separate rooms. The participants were asked to trial the software by working through a design task. They found that the turn-taking procedure worked well but that verbal communication still took place through the walls. This time, however, discussion was focussed on aspects of the collaborative task and its screen design. This suggested the need for a communication tool to be added to the interface so that discussion between participants could take place independently of the work taking place on the design area. This feature was added in Stage 3.

Stage 3. In Stage 3, a dialogue tool, the Discussion Room, was added to the interface by means of a text-based pad (see Figure 2 right hand side). At this stage the software was tested by a cognitive walkthrough with groups of HCI staff and students. Participants agreed that the Discussion Room adequately removed the need for

---

[1] **PHP** is an open-source programming language used mainly for producing dynamic web content and server-side applications and can interact with many relational database management systems.

oral communication. It avoided the problem of long down-time for three of the participants while the fourth was working on the screen by enabling each of the 4 participants to interact at any time by text message.

At this time other problems became evident. Participants were overdrawing each other's work and they were without recourse to a history of previous design features.

Stage 4. To alleviate the problem of overwriting, a 'roll-back' feature was added to the software so that the history of the development of a collaborative design could be reviewed at any point in the process (see Figure 2). To achieve this, each contribution by Manager, Designer, Technician and User was saved as a separate file and not overwritten by later contributions as in the earlier versions. Each participant had write access to their own contributions only, which they could amend/erase as required. The other three participants could review all the earlier stages but with read access only to the contribution of the others. It was observed that this feature encouraged discussion between participants regarding their collaborative design. The roll-back feature complemented the Discussion Room in providing a complete audit trail of the design process in a virtually effortless way for the participants.

The rollback feature also provided the evidence and history that is generated by the video capturing that is part of the traditional PICTIVE process.

Stage 5. At this final stage, software was released to off-campus students for pilot testing with a typical HCI assignment which involved designing a remote control for an interactive office. Students were required to use PICTIOL as their collaborative design environment. As part of the regular feedback review process, students stated an appreciation of the system. In particular, the time variation for the Singapore student meant that she could contribute over an extended period of time, whereas the Australian-based participants preferred to organize a common time to utilize the system and to collaborate in real time. Staff noted that students used the Discussion Room effectively but also used email and telephone to share ideas.

Feedback from off-campus students, both in Australia and overseas, indicated that performance of the software was not diminished in remote locations. PICTIOL is not resource-hungry, requiring minimal data to be sent through communication channels. A few functional glitches in the tool were identified by the students, however. These produced a degree of frustration, but only at the operational level and so PICTIOL functionality still requires refinement. Generally, for the purpose of collaborative design, the tool was considered to be valuable and well worth pursuing.

Staff noted that the PICTIOL screen design was effective in keeping the student designers focused on the design task. This appears to be a result of having the design area and the Discussion Room side-by-side in view at all times.

In reflecting on the actual software development process of the PICTIOL system it was noted that the software developer participated in the walkthroughs and testing at every stage, thus gaining a precise understanding of the additions and changes required. This is consistent with the principles outlined by Gould and Lewis (1985) leading to a 'useful and easy to use computer system'. Development time was not wasted on unnecessary additions, but rather the recommendations of users and/or observers of the usability tests were directly addressed.

DISCUSSION

The PICTIOL project is valuable on two levels. Firstly, it provides off-campus students with a valuable learning experience, otherwise inaccessible to them. Secondly, it is itself a case study in the effectiveness of the participatory design approach to software design. In this case the software being designed was itself a participatory design tool.

Benefits of PICTIOL for distance education

The PICTIOL software, even at the current prototype stage of its development, has allowed off-campus and part-time students to participate in a participatory design experience which they could not do otherwise. Off-campus students were able to collaborate effectively to produce a design of a sufficient standard to give a software developer appropriate criteria for its implementation. Collaboration between manager, designer, technician and user from the beginning of the project is regarded as a crucial component of this process. The software developer can begin development with a full understanding of the needs of each the different stakeholders because he/she has interacted with them by discussion and sharing the process of designing the graphic interface. This is a learning objective that is highly desirable for students going into industry.

The PICTIOL graphic interface is non-threatening and easy to use. Its design not only encourages participation, it focuses students on the design task. It enables off-campus students to:

- design a prototype graphic interface very quickly;
- engage in direct and instantaneous communication;
- use appropriate protocols for taking turns;
- respond to feedback;
- review progress at any stage;
- collaborate on an authentic task;
- acknowledge the role of all stakeholders by accepting a particular role which is typical of relevant roles in the workplace.

PICTIOL not only retains many of the desirable features of the PICTIVE technique, it addresses some of its limitations. For example, the video recording technique for storing the progress of a PICTIVE design process was found to be cumbersome and impractical in practice (Muller, 1992). By contrast, PICTIOL users have an efficient means of storing and retrieving any stage of the design process. In addition, a complete record of the text in the Discussion Room is available to all participants. This serves as a permanent record of the progress of the design process. Thus reasons for particular design decisions are readily available to all for review at any stage. This feature was noted as particularly important to design teams in the workplace (Herbsleb and Kuwana, 1993).

PICTIOL enforces the importance of the contributions of the different stakeholders in the end product. It requires each participant in the design group to adopt a different role. In particular, as well as the interface designer and the software engineer, the essential roles of end user and senior management are emphasised. Such role playing, even for experienced design teams, makes the different perspectives clearer to the designers (Nielsen et al., 1992).

In a distance education setting, PICTIOL of itself cannot give students a full appreciation of the importance of the participatory design methodology (see the basic guidelines described above). Although each student is required to adopt a particular role as either a manager, designer, technician or user, these roles cannot be enforced during the design activity, nor is this desirable, given that all participants are to be treated equally. The importance of the recognition of all end-users in the design of both hardware and software cannot be over emphasised, however, and is stressed throughout the course.

In practice, providing suitable conditions for non-technical users to contribute effectively to the design phase is far from easy. Wilson et al. 1997) observed a considerable number of 'obstacles' as well as 'facilitators' to user participation during the development of a bespoke application in a large company. Nevertheless, the successes of the 'Scandinavian approach' continue to provide a desirable goal.

PICTIOL in the workplace

The methodology described in this paper is appropriate to the workplace, particularly in situations in which the stakeholders are located at a distance and when finding a time to meet presents problems. The PICTIOL concept provides the benefits of participatory design without the need for costly travel and the associated loss of time.

PICTIOL may appear to computer professionals to present a rather amateurish interface. This, however, is one of its strengths. It is indeed a major strength of the PICTIVE approach as envisaged by its creator (Muller, 1991). Visual simplicity and ease of use encourages input by participants at all stages of familiarity with computers. The protocols enforced in the software simulate those operating in face-to-face groups. Appropriate turn-taking is effected by the turn-taking avatars. Interaction and feedback primarily by means of a relatively simple tool, the Discussion Room, was observed to generate lively and constructive discussions.

Another benefit of PICTIOL as a design tool is the provision of easily recognized widgets such as buttons which can be labeled and placed anywhere on the design area. The button shape immediately indicates to all participants the type of function required. This is especially useful to the developer when it comes to an implementation phase of the project.

Keeping a record of stages in the design process and reasons for design decisions is a feature of PICTIOL. The importance of this for a collaborative project was pointed out by Herbsleb and Kuwana, (1993). In contrast with private note taking, the PICTIOL roll-back feature and the ability to access all past dialogue which had occurred in Discussion Room enabled equal access to development trail for all the participants.

The value of 'pencil and paper' as opposed to informal computer design tools continues to be emphasised by some researchers (Bailey and Konstan, 2003, Cook and Bailey, 2005). They claim that paper facilitates communication of ideas to a client, promoting effective social interaction and immediate feedback. In addition, extensive annotation can be achieved without additional performance overhead (Cook and Bailey, 2005). The authors of the present paper fully appreciate these findings but recognise that a compromise is required when the group members are separated by distance. We believe that PICTIOL has a sufficiently low-fidelity feel to encourage non-professional participation, and that adequate social interaction and immediate feedback are achieved using the Discussion Room. Although some of the convenience of paper is lost, a computer-based design space offers advantages: for example, designs are easy to edit, store, duplicate and retrieve, i.e. the design history is easily reviewed.

The Low-Fidelity vs High-Fidelity debate is an ongoing controversy (Rudd et al., 1996). A useful set of key points to consider when deciding between a high-fidelity and a low-fidelity prototyping tool has been published by Rudd et al (1996). Creative interface design is an art as well as a science, requiring both technical skill and sensitivity to users' real needs, whether expressed or implied, but frequently constrained by lack of time and resources. Selection of the appropriate design technique will be determined by the particular problem.

Future plans for the software include the provision of a feature to enable visualization of drop-down menus. For example, overlay screens (transparent unless an icon placed on them) would be a useful addition to the application.

CONCLUSIONS

The PICTIOL project involved the development of software designed to provide a shared workspace to allow participants separated by distance to undertake collaborative design akin to the PICTIVE technique. The software mimics salient features of 'paper and pencil' interface design, enabling the students to take part in a collaborative problem-based learning experience and thus gain an appreciation of the benefits of low fidelity prototyping. It provides a dynamic environment enabling both synchronous and asynchronous collaboration. The system was designed specifically for off-campus students however several benefits for industry were also identified.

Whilst the focus of the project was on the development of a specific tool, it is also a case study in the effectiveness of the participatory design approach to software design. In this case the software being designed was itself a participatory design tool where the full range of stakeholders was involved in the design and development process.

ACKNOWLEDGMENTS

The authors sincerely acknowledge the contribution of Matthew Bretag, Swinburne University of Technology, to the project. Mathew's expertise and hard work were invaluable in the design and development of the PICTIOL software. The authors also thank Debbie Sage for her contribution to the design and development of the project in its early stage.

REFERENCES

Bailey, B. P. & Konstan, J. A. Are Informal Tools Better? Comparing DEMAIS, Pencil and Paper, and Authorware for Early Multimedia Design. In Proc. CHI 2003, ACM Press (2003), 313-320.

Chandler, C. D., Lo, G. & Sinha, A. K. Multimodal Theater: Extending Low Fidelity Paper Prototyping to Multimodal Applications. In Ext. Abstracts CHI 2002, ACM Press (2002), 874-875.

Cook, D. J. & Bailey, B. P. Designers' Use of Paper and the Implications for Informal Tools. In Proc. OzCHI 2005, (2005), Long papers.

Everitt, K. M., Klemmer, S. R., Lee, R. & Landay, J. A. Two worlds Apart: Bridging the Gap Between Physical and Virtual Media for Distributed Design Collaboration. In Proc. CHI 2003, ACM Press (2003), 553-560.

Floyd, C., Mehl, W.-M., Reisin, F.-M., Schmidt, G. & Wolf, G. Out of Scandinavia: Alternative Approaches to Software Design and System Development. *Human-Computer Interaction,* 4**,** 4 (1989), 253-350.

Gould, J. D. & Lewis, C. H. Designing for usability: key principles and what designers think. *Communications of the ACM,* 28**,** 3 (1985), 300-311.

Herbsleb, J. D. & Kuwana, E. Preserving knowledge in design projects: What designers need to know. In Proc. CHI 1993, ACM Press (1993), 7-14.

Jones, D. (1996). What is PBL?, http://edweb.sdsu.edu/clrit/learningresource/PBL/WhatisPBL.html. Accessed May 2006.

Landay, J. A. & Myers, B. A. Interactive Sketching for the Early Stages of User Interface Design. In Proc. CHI 1995, ACM Press (1995), 7-14.

Liu, J.-S. & Sycara, K. P. Multiagent Coordination in Tightly Coupled Task Scheduling [Online], http://www.it.iitb.ac.in/~umesh/agents/Multiagent%20Coordination%20in%20Tightly%20Coupled%20Task%20Scheduling%20(1996).pdf. Accessed June 6, 2006.

Miller, D. S., Smith, J. G. & Muller, M. J. TelePICTIVE: computer-supported collaborative GUI design for designers with diverse expertise. In Proc. UIST 1992, ACM Press (1992), 151-160.

Muller, M. PICTIVE - An exploration in participatory design. In Proc. CHI 1991, ACM Press (1991), 225-231.

Muller, M., Blomberg, J., Carter, K., Dykstra, K. & Madsden, K. Participatory design in Britain and North America: Responses to the "Scandinavian Challenge". In Proc. CHI 1991, ACM Press (1991), 389-392.

Muller, M. J. Retrospective on a year of participatory design using the PICTIVE technique. In Proc. CHI 1992, ACM Press (1992), 455-462.

Newman, M. W., Lin, J., Hong, J. I. & Landay, J. A. DENIM: An Informal Web Site Design Tool Inspired by Observations of Practice. *Human-Computer Interaction,* 18**,** 3 (2003), 259-324.

Nielsen, J. (1994). Ten Usability Heuristics [Online], http://www.useit.com/papers/heuristic/heuristic_list.html, Accessed June 5, 2006.

Nielsen, J., Bush, R. M., Dayton, T., Mond, N. E., Muller, M. J. & Root, R. W. Teaching Experienced Users to Design Graphical User Interfaces. In Proc. CHI 1992, ACM Press (1992), 557-564.

Pross, H. (2002). Problem-based learning: Student-Tutor Handbook. Faculty of Health Sciences, Queen's University, Kingston, Ontario, http://meds.queensu.ca/medicine/pbl/PBLHndbk2002.pdf. Accessed May 2006

Rudd, J., Stern, K. & Isensee, S. The Low vs. High Fidelity Prototyping Debate. *Interactions,* 3**,** 1 (1996), 76-85.

Spencer, R. The Streamlined Cognitive Walkthrough Method, working around social constraints encountered in a software development company. In Proc. CHI 2000, ACM Press (2000), 353-359.

Trigg, R. (1995). Participatory Design: Notes from a classic article by Kristen Nygaard: Nygaard, K. (1975). Kunnskaps-strategi for fagbevegelsen (Skills strategy for trade unions). Nordisk Forum 6, 10(2), 15-27. , http://www.cpsr.org/prevsite/program/workplace/nygaard-75-notes.html. Accessed May 2006.

Trigg, R. & Clement, A. (2000). Participatory Design [Online], http://www.cpsr.org/prevsite/program/workplace/PD.html/. Accessed May 2006.

Wharton, C. W., Reiman, J., Lewis, C. H. & Polson, P. (1994) The cognitive walkthrough method: A practitioner's guide. In Nielson, J. K. & Mack, R. L. (Eds.) *Usability Inspection Methods.* New York, Wiley.