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# The Lids Research Project
# Usability Study Report [1/2002]

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# Executive Summary

This report represents the University of Waikato Usability Laboratory's (Usability Laboratory) analysis of the Large Interactive Display Screen (LIDS) technologies as developed by the LIDS Research Group.[1]

The Usability Laboratory conducted three exploratory-type studies of the LIDS technology over January and February 2002. The studies each focused on individual elements of the LIDS technology, while at the same time contributing to the general understanding and knowledge of the technology.

The first study, Technology for Use for Teachers and Students, focused on the support that the LIDS technology provided for both the in-class presentation of learning information and the after-class review of the learning material. The second study, Interactive Gesture Recognition, focused on the use of sometimes-used gestures (on-screen strokes) that provided the ability to navigate a LIDS presentation. The third study, Shadow Technology, focused on the use of a shadow to facilitate awareness between LIDS users in distributed locations.

The Usability Laboratory also conducted a heuristic evaluation of the presentation review tool associated with the first usability study, Technology In Use for Teachers and Students, so as to highlight areas of the tool that could be improved upon. From the three studies, and also previous observations, the Usability Laboratory has also observed some interesting ergonomic issues regarding the physical LIDS technology.

This report presents findings of each of the studies, the separate heuristic evaluation of the presentation review tool, and observations of the physical technology. The findings are separated into usability problems and usability benefits. For every benefit we highlight, we provide a general description and discuss the participants' thoughts. For every problem that we describe, we indicate the relevant usability principle (or principles) broken, and try to recommend at least one design solution to the problem, although a range of alternate design solutions are generally sought. These should be used as the basis for further discussion rather than being the ultimate and final resolution. As such, and where applicable, we discuss the usability advantages and disadvantages of each recommendation given. Where possible, we have provided graphic examples.

## Findings in Summary

Many participants understood the value and could see many benefits of LIDS. They appreciated its utility, found it easy to use and enjoyed working with it. The usability benefits and problems discovered during the studies, the heuristic evaluation and observation, are briefly discussed below. Before doing so, we highlight what we believe are the three most important aspects of the technology that should be solved first.

1. The most import aspect of the LIDS technology to solve is its technical instability. During all three usability studies bugs in the software caused problems for the participants. This meant that the participants focused more on the technology than on their tasks or their collaboration.

[1] The LIDS Research Group is part of the HCI Research Programme in the Department of Computer Science at the University of Waikato, Hamilton, New Zealand.

2. The second most important feature that should be solved is the lack of an undo feature. The inclusion of this feature will mean that incorrectly drawn gestures or unintentional collisions with existing gestures can be fixed by the user when using LIDS.

3. The third most important element that should be solved is the delete gesture. This caused major problems for most of the participants including the lecturer (Bill Rogers) in the first usability study. (Bill Rogers implemented the interactive gesture recognition tools and was more experienced with using the gesture set than any of the other participants.) We recommend that if possible, the delete gesture be replaced with the Mimio™ eraser.

A further important aspect of LIDS that will need to be investigated further is the physical LIDS technology. It is important that the quality and attractiveness of the technology be improved, to increase the adoption of LIDS with a range of solutions. We have highlighted a number of usability problems with regard to the Mimio™ pen and the LIDS screen.

**Usability Study 1: Technology in Use for Teachers and Students**

Our usability study of LIDS in use as a presentation and learning support tool for a lecture situation found that in general the participants viewed the technology positively. They indicated that it was as good as, if not better, than other more traditional or better-known presentation media (such as blackboard, whiteboard, OHP or Powerpoint™). The participants also liked being able to review material online after the lecture as it allowed them to reinforce or improve upon what they had learnt in class.

However, our usability study also highlighted elements of the technology that forced the users to focus on the technology rather than their tasks or the collaboration taking place. These include poor visibility and readability of the LIDS screen, and the technical instability of the LIDS software for presentation and review. The latter should be the first priority to solve. These benefits and problems are discussed in more detail in section 3 of this report.

**Usability Study 2: Interactive Gesture Recognition Tools**

Our usability study of the LIDS interactive gesture recognition tools established that most participants found all of the gestures (except the delete gesture) easy to use, simple and reliable. The delete gesture proved to be a problem for most participants. All the participants indicated that they enjoyed using the LIDS technology and the gesture recognition tools to perform their presentations.

Several usability problems, other than the use of the delete gesture, were also found. These include gestures being drawn incorrectly, a lack of an easy undo mechanism, unclear software modes/states, collisions with unintentional gestures, hidden on-screen software options, difficult readability of on-screen user-drawn text, and a restricted set of interactive gestures. These benefits and problems are discussed in more detail in section 4 of this report.

**Usability Study 3: The Shadow Technology**

Our usability study of the LIDS shadow technology established that most of the participants were generally positive about the use of the shadow to support awareness of other users during distributed collaborative activities. However, the participants indicated that they were not confident that the other user was aware of what they were doing. Further, they suggested that their interaction and communication with the other user was not as good as working in the same room together or even working in two separate locations that had no shadow. We believe that this is due to the nature of the tasks, which became competitive events in most sessions. We also believe that the very existence of the shadow did not encourage the participants to talk about what they were doing; instead, they tended to rely purely on the shadow for support and awareness. These benefits and problems are discussed in more detail in section 5 of this report.

**The Presentation Review Tool (A Heuristic Evaluation)**

Our heuristic evaluation of the presentation review tool highlighted several additional usability problems to those observed during the first usability study, that will need to be solved for users to gain further satisfaction from using the tool. We suggest that the tool lacks a number of features, in particular previous slide and next slide buttons. Further, a number of features that already exist with the tool need to be improved. These features include the audio bar and the table of contents pages. These problems are discussed in more detail in section 6 of this report.

**The Physical Technology: Ergonomic Issues (An Observation)**

During our usability studies we observed that the participants generally liked the Mimio™ pen, appreciating that it not only replaced the mouse but that it did so in an easier, more natural way. Similarly, we found that the participants really enjoyed interacting with the large screen. When used in combination with the pen and interactive gestures, we observed the participants acting in a natural, open and interactive manner.

However, a number of ergonomic issues exist. For the screen, these included its inflexible height and physical detachment from the computer keyboard. For the pen, the ergonomic issues included its large and bulky size and shape, which made it difficult to grip and write on the screen with ease. These benefits and problems and other usability problems associated with the screen and pen are discussed in more detail in section 7 of this report.

**Summary**

Improving the usability of the LIDS software (the presentation tool, the presentation review tool, the interactive gestures and the shadow technology) and physical technology (the pen and LIDS screen) will promote better use of LIDS by users. Users will be better able to interact with other users, whether in a distributed setting or within the same room, share the same artefacts equally, and collaborate over the same goals and tasks more easily. The most successful environment will allow users to feel comfortable with the technology, be aware of what other users are doing, and enable the users to feel that they have met their goal-oriented tasks satisfactorily.

## Implications for LIDS

From our studies we learnt that LIDS provides the development and delivery of material in a flexible and transparent manner. Existing material can be shared, and the WYSIWYD (What You See I What You Do) environment enables important information to be easily highlighted and new material added in a way that strongly supports the spontaneity and natural evolution of a collaborative setting.

The stand out feature was its simplicity—an attraction for both experienced and inexperienced computer users. We found many of its implemented features were easy to use.

We suggest that the LIDS technology has potential for a wide range of collaborative events, such as design sessions, learning sessions for children and the disabled, information/data sharing and discussions, and meetings and presentations. Being computer driven means that it can be expanded and integrated with other computer technologies to meet the needs of specific applications, which may include online learning, data collection and dissemination with the support of such technologies as small screen devices for areas such as health and law enforcement.

## Author

The report has been written on behalf of the University of Waikato Usability Laboratory by Kirsten Thomson and Laurie McLeod. For further information or queries related to this document please contact Kirsten Thomson (email: kthomson@cs.waikato.ac.nz, phone: 07 858 5116).

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# 1. Introduction

The Large Interactive Display Screen (LIDS) Research Project has developed the LIDS technology—a collaborative product—as part of the HCI Research Programme.

## 1.1 The LIDS Research Project

Large display screens have long been an important medium for teaching and business presentations. They enable the presenter to share a visual space with the audience. Simple passive systems, such as blackboards and whiteboards, offer transparency of use and permit spontaneity in presentations. Projection systems offer superior quality images, sound and animation, but the material must be prepared in advance and cannot be altered significantly during a presentation. More recently, video projection from a computer has become a popular large screen presentation tool. It offers greater flexibility than film or slides, in that the presenter can interact with the presentation and make changes on the fly, but this usually means disengaging from the audience in order to manipulate the keyboard or mouse. The LIDS project exploits recent developments in low-cost large-surface digitising, in conjunction with computer projection, to allow the presenter direct control from the display screen surface itself.

**Project Objectives**

The objectives of the LIDS Research Project have been to explore the application of such technologies, with particular reference to teaching (the re-delivery of lectures), meeting support (in single and multiple sites), and personal information management (to replace the office whiteboard).

**Research Partners**

The LIDS Research Project is a joint project between the University of Waikato (UoW), Auckland University of Technology (AUT), and the University of Auckland (UoA).

**Research Funding**

The project has been funded by the Foundation for Research, Science and Technology (FoRST) through the New Economy Research Fund (NERF).

## 1.2 LIDS Research and Development

Much development work has been carried out since the LIDS Research Project began. During the first stage a range of activities have taken place. These include:

- The development of a number of portable screens.
- The research and development of suitable optical techniques to enable the screens to be as compact as possible.
- The research and development of software tools to enable annotation overlays and audio synchronization on standard Powerpoint™ desktop productivity software.
- The research and development of a set of basic recognition tools, building intelligence into these graffiti actions, such as cross-outs, underlines, inserts, and arrows, etc.
- The definition of a taxonomy of gestures and actions appropriate and natural in the context of LIDS and that extend and enhance actions common in the existing computer desktop metaphor.

- The research and development of a "shadow" video prototype software that operates effectively and seamlessly with other LIDS applications and computer desktop tools, as a screen backdrop.

Consideration has also been given to adapting the Mimeo™ pen technology currently in use with LIDS to provide a greater variety of interaction techniques.

It has been relatively important that these developments be tested to determine their utility and usability for the intended product users, taking into account the collaborative nature of the product.

## 1.3 LIDS Usability Studies

The Usability Laboratory has carried out three exploratory-type studies on the LIDS technology over January and February 2002. Each focused on individual elements of the LIDS technology, while at the same time contributing to the general understanding and knowledge of the technology.

**Usability Study 1: Technology in Use for Teachers and Students**

The main purpose of this study was to explore the collaborative support for an interactive group within a classroom environment where LIDS was used as the predominant information display and interaction medium. The study was used to determine whether the technology would adequately support the information gathering and presentation needs of both the teacher and the students, and whether this medium enables adequate learning both within the classroom situation and outside the class environment.

**Usability Study 2: Interactive Gesture Recognition**

The main purpose of this study was to explore the use of the interactive gesture recognition tools (to explore and manipulate) by users when using Powerpoint™ on LIDS. The study endeavored to discuss from the participants the ease or difficulty they had using the gestures.

**Usability Study 3: Shadow Technology**

The main purpose of this study was to explore the performance of two distributed (i.e. not co-located) participants using LIDS with the shadow technology. The study involved the participants (i) using LIDS when in the same room (in a non-distributed environment) sharing one LIDS and one pen, (ii) using LIDS in separate rooms but without the shadow technology, and (iii) using LIDS in separate rooms with the shadow technology. The participants were compared in their use across all three situations. The study endeavored to learn from the participants the ease or difficulty they had with the tasks and how useful they found the technology for distributed group work.

## 1.4 Heuristic Evaluation

As an extension of the first usability study, Technology in Use for Teachers and Students, the Usability Laboratory has also carried out a brief heuristic evaluation (expert review) of the presentation review tool. The purpose was to identify areas of the technology not highlighted by the participating students in the first study that required improvements and to identify possible alternatives to how the technology was being portrayed to the users.

## 1.5 The Physical Technology

All three usability studies and our own previous observations were also used to ascertain the participants' ergonomic and interaction experiences with the LIDS technology. The purpose of this was to identify areas of the technology that required improvements and to identify possible alternatives to how the technology was being portrayed to the users.

## 1.6 Terminology

A number of specific terms have been used in this report. These are listed below in Table 1.1.

| *Term* | *Description* |
|---|---|
| user | Throughout this report, the term "user" or "end user" has been used to refer to the real intended end user of the of the technology. |
| participant | Throughout this report, the term "participant" has been used to refer to those users who helped test the usability of the technology. |
| LIDS technology | Throughout this report, the terms "LIDS technology" and "LIDS" have been used to refer to aspects of the LIDS software and hardware that have been the focus of the usability studies. |
| section | Throughout this report, the term "section" has been used to refer to the main sections of this report. |

*Table 1.1 Terminologies used in this report.*

## 1.7 Typographic Styles

A number of typographic styles are used in this report to indicate participant users' comments and particular aspects of the application interface. These are listed below in Table 1.2.

| *Typographic Style* | *Description* |
|---|---|
| User Comments | Throughout this report, a participant number attributes comments by a participant. The comments are indented and italicised. For example, participant 2 (P2) made the following comment:<br>*"...the shadow was really cool." (P2)*<br>Where none exist, comments that could not be attributed to a specific attribute. |
| Interface Artefacts | Throughout this report, any existing interface buttons or menu options are written in the Arial font. For example, the Start button is written as Start. |

*Table 1.2 Typographic styles used in this report.*

## 1.8 Structure of the Report

The remainder of this report is structured as follows. Section 2 describes the LIDS technologies. Section 3 describes results from usability study 1. Section 4 describes results from usability study 2. Section 5 describes the results from usability study 3. Section 6 describes the results from the heuristic evaluation of the presentation review tool. Section 7 describes problems and benefits of the physical LIDS technologies. The final section of the report, section 8, presents some concluding remarks and a summary of the design recommendations.

In the appendices you will find a list of usability principles (appendix 1) that have been used within this study, a commentary on usability testing collaborative technologies (appendix 2), interim reports for the three usability studies (appendices 3, 4 and 5), and an interim report on the observation of the physical LIDS technology (appendix 6). Appendix 7 lists the technical breakdowns that occurred during the three usability studies. Finally, the bibliography is attached at the end of this report.

# 2. The LIDS Technology

The LIDS Research Project have constructed their own LIDS screens that are used in conjunction with rear-computer projection (see Figure 2.1). A Mimio™ digitiser sits on one side of the screen and captures the presenter's on-screen movements. These movements include interactive gestures that are used to explore the presentation (such as moving between Powerpoint™ slides) or record annotations. On-screen movements and explorations are performed with a pen-like device. The off-screen movements (such as moving sideways) of the presenter is able to be recorded and displayed on the screen as a shadow. The presentation is able to be stored on computer and made available for on-line review after the presentation.

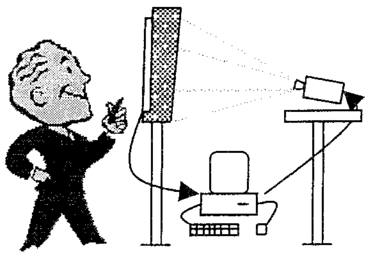


*Figure 2.1 The LIDS technology at a glance.*

## 2.1 The Mimio™ Technology

Much of the motivation behind the LIDS project stems from the appearance during the latter half of 1999 of the Mimio™ whiteboard digitiser. (The Mimio™ whiteboard digitiser is made by Virtual Ink. (For more details see http://www.mimio.com/meet/win.) This low-cost device (NZ$1500) is intended to provide a means of capturing pen movement on a conventional whiteboard surface. It can accommodate surfaces up to 2400mm by 1200mm, and has provision for 4 separate pen colours and 2 erasers. Mimio™ is delivered with mouse emulation software, enabling a whiteboard pen to substitute for the mouse on a Windows™ computer. An earlier simple experiment carried out by the LIDS Research Project has shown that coupled with a rear-projected display screen, Mimio™ can deliver a large interactive display surface similar to a Liveboard, but at a fraction of the cost.

### The Mimio™ Digitiser

The Mimio™ digitiser was originally designed to sit on one side of a whiteboard (see Figure 2.2). The digitiser is attached to a computer, which in turn is attached to a projector.

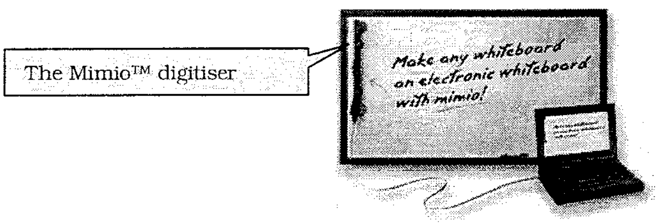



*Figure 2.2 The Mimio™ digitiser.*

When used with a whiteboard the image is front-projected. As the presenter writes or draws on the whiteboard, his or her movements are captured electronically onto the computer. The resulting file can be saved and shared appropriately.

**The Mimio™ Pen**

The Mimio™ pen (see Figures 2.3 and 2.4) is a capsule-type device that fits a 'plastic pen' similar to that used for whiteboards.

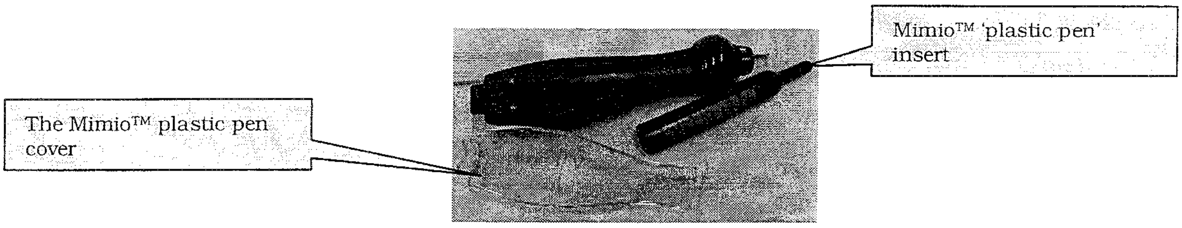



*Figure 2.3 The separate Mimio™ pen parts.*

The 'plastic pen' used in the Mimio™ pen has a hard plastic nib. After some use, the LIDS Research Project found the hard nib uncomfortable to use. They have now replaced the 'plastic pen' with a used whiteboard marker containing no ink. This provides a softer tip that grips the surface of the screen more easily than before.

The part of the Mimio™ pen that is held by the user curves outwards to the end of the pen.

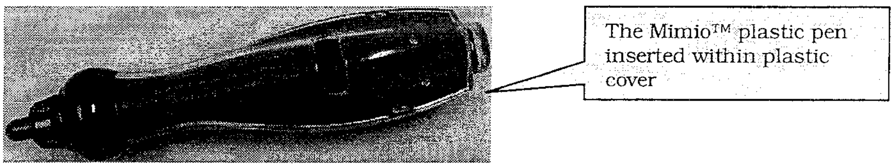



*Figure 2.4 The Mimio™ pen as one piece.*

The original Mimio™ pens come in four colours: black, red, blue or green. To change colour the user needs to pick up the pen that held the desired colour and use it in place of the pen that they were currently using. The LIDS Research Project has provided a means for changing the pen colour through the software. The users can do so by clicking on a Start button in the left-hand bottom corner of the LIDS interface.

**The Mimio™ Eraser**

The Mimio™ eraser (see Figures 2.5 and 2.6) is round (to fit in the palm of the user's hand) and flattish. It sits in it's own pocket (see Figure 2.5), that can be attached to the side or bottom of the screen.

The eraser has two eraser heads: one round and large that sits at the bottom of the eraser (see (i) in Figure 2.6); the other is smaller and is attached to the side of the eraser (see (ii) in Figure 2.6).

## 2.2 The Large Display Screen

As described above, the Mimio™ digitiser was originally designed to attach to a whiteboard, and to be used with front-projection. The LIDS Research Project, seeking portability and the ability to conduct a presentation in a distributed environment, have designed LIDS to be used with rear-projection.

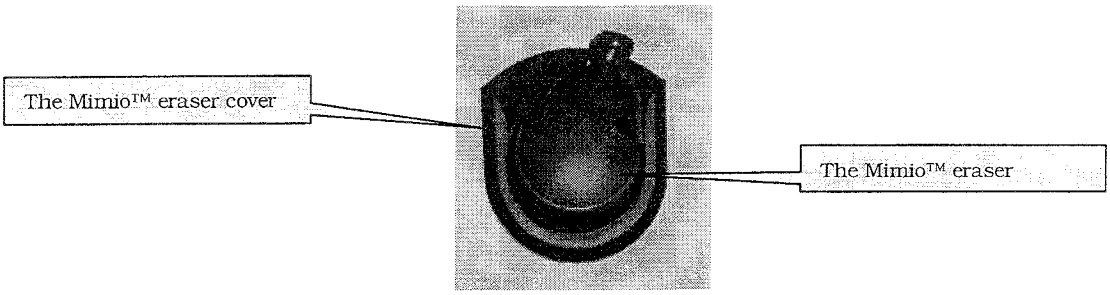



*Figure 2.5 The Mimio™ eraser inside it's own pocket. The pocket can be attached to the side or bottom of the screen.*

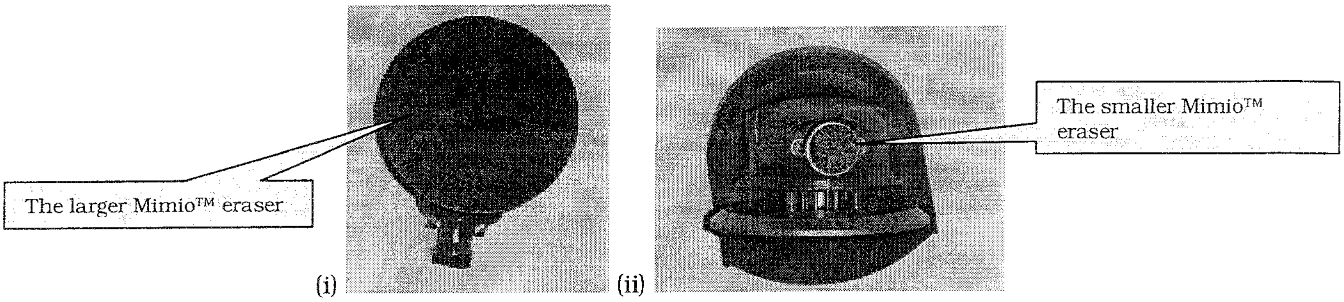



*Figure 2.6 The erasing points to the Mimio™ eraser. In (ii) the eraser is sitting side ways on top of the eraser pocket.*

The LIDS Research Project have conceived a number of ways of constructing a large display surface to accommodate rear-projection. These include the use of a large piece of glass, backed with thick draughting paper; two pieces of glass with plastic layered between; and a large piece of flexible plastic.

The screens used for the studies conducted by the Usability Laboratory were the glass versions.

## 2.3 Interactive Gestures

To explore (e.g. move between Powerpoint™ slides) or manipulate the presentation, the LIDS Research Project have incorporated interactive gestures. These gestures are made by the user with the Mimio™ pen on the screen. A range of gestures have been implemented (see Table 2.1). The shape and form of the gestures have been designed to enhance the whiteboard paradigm.

## 2.4 The Presentation Review Tool

The sequence of interaction and edit events in a presentation are captured by the computer. The end result is a file that contains the original presentation, alterations to the presentation and exploration of the presentation. For example, say a presenter prepared a five slide presentation in advance. As the presenter moves between each slide, the path of exploration is recorded and upon review each slide is listed in the same order as the path of exploration. Thus, if the presenter visits the slides in the following order, 1,2,3,4,3,4,5, then the review tool presents these slides in the same order. If the presenter makes annotations to an existing slide then these are recorded and on review are presented on the appropriate slide. Any slides that are created during the presentation, having been appended to the end of the presentation after the last slide are also made available for review.

The review facility is an online (Internet/Intranet) tool.

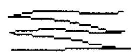
| *Name* | *Gesture* | *Description* |
|---|---|---|
| Next slide |  | The next slide gesture is used for moving forward to the next slide in the presentation. This entails the user drawing a horizontal line from left to right on the screen, and then drawing the line back on itself for a distance. (This is analogous to a right-facing arrow in which the arrowhead is very narrow.) Moving forward to the next slide saves any text or drawing that has been added to the slide. |
| Previous slide |  | The previous slide gesture is used for moving back to the previous slide in the presentation. This entails the user drawing a horizontal line from right to left on the screen, and then drawing the line back on itself for a distance. (This is analogous to a left-facing arrow in which the arrowhead is very narrow.) Moving back to the previous slide saves any text or drawing that has been added to the slide. |
| Erase all |  | The erase all gesture is used for erasing the contents of the slide. This entails the user drawing a vertical line from the top to the bottom of the screen, and then drawing the line back on itself for a distance. (This is analogous to a down-pointing arrow in which the arrowhead is very narrow.) Only text or drawings that have not been saved can be deleted in this way. |
| Delete |  | The delete gesture is used for deleting an object on the slide in the presentation. This entails the user drawing five zigzag lines back and forth over the object in such a way as to create the corners of a box that completely encompasses the object to be deleted. The gesture has to begin in a bottom corner and zigzag upwards. Only text or drawings that have not been saved can be deleted. |
| Finish and save |  | The finish and save gesture is used for finishing and saving the presentation. This entails the user drawing a vertical line from the bottom to the top of the screen, and then drawing the line back on itself for a distance. (This is analogous to an up-pointing arrow in which the arrowhead is very narrow.) |

*Table 2.1 LIDS gesture set.*

**Process of Use**

The first screen that the users see is a table of contents (see Figure 2.7 and below for a fuller description).

The user locates the slide that he or she wishes to review and then selects the slide with the computer mouse. The slide then becomes 'live', replacing the table of contents page, and the audio recording for that slide begins to play automatically (see Figure 2.8).

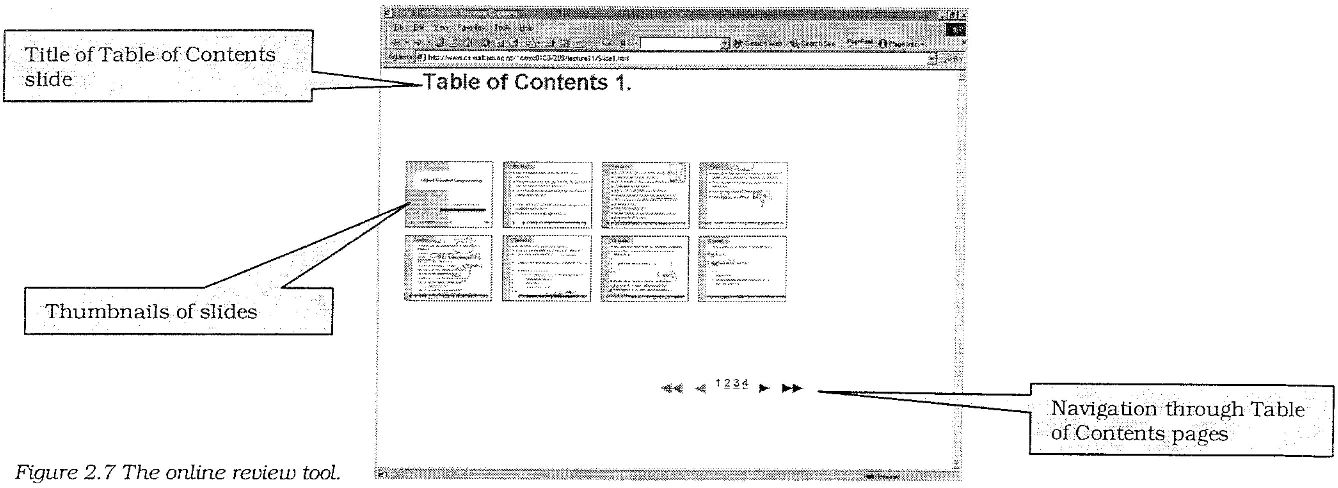



*Figure 2.7 The online review tool.*

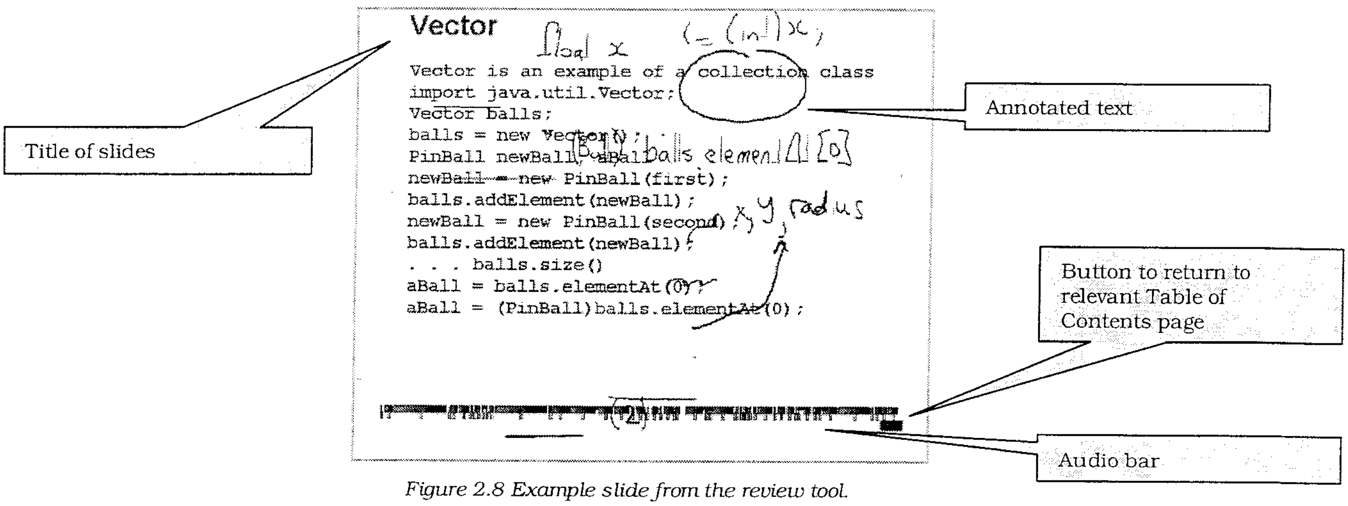



*Figure 2.8 Example slide from the review tool.*

## The Table of Contents

The table of contents (see Figure 2.7) currently consists of one or more screens with each screen containing a two-by-four matrix of slides. If more than eight slides exist in the presentation then additional table of contents screens are provided. Arrows, displayed at the bottom of the table of contents screens, enable the user to navigate to the first (◀◀), previous (◀), next (▶) and last ( ▶▶) table of contents slides. A numeric list (e.g. 1 2 3 4), that represents each of the table of contents slide, is also given. The numbers are underlined to indicate that these are navigable. On selection the user is able to navigate directly to a particular table of contents screen. Each table of contents screen also displays the title "Table of Contents" and a number to represent the table of contents screen that the user is currently viewing. Thus, the second table of contents screen would have the title "Table of Contents 2.".

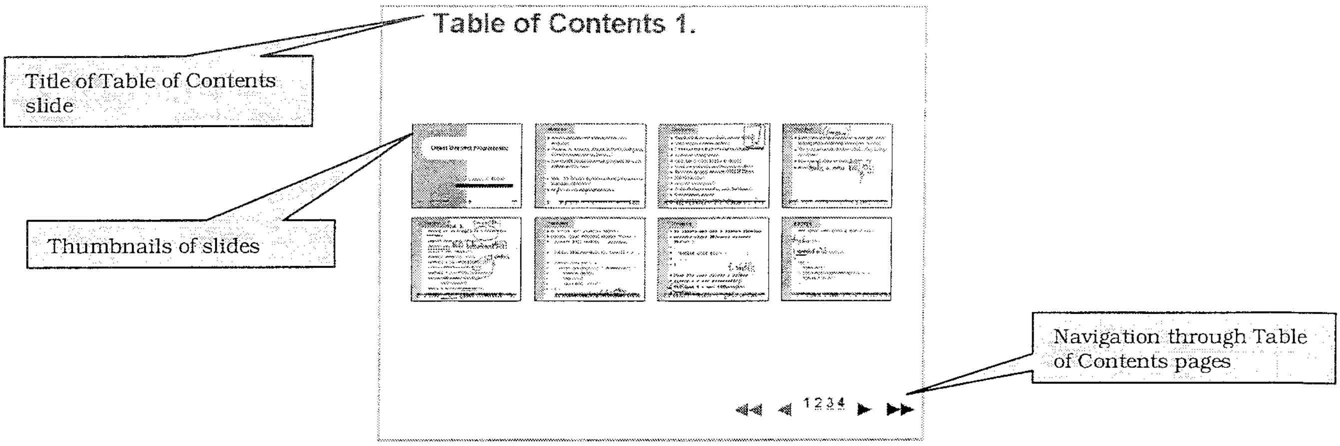



*Figure 2.9 An example table of contents screen from the review tool.*

**Features of the Slides**

Each slide contains the visual/textual presentation (including annotations), as well as an audio bar which is located at the bottom of the screen (see Figure 2.8). The audio bar is used to indicate the saved audio file for that slide. The audio bar represents the audio file in blocks—pauses in the audio are represented by breaks in the bar. Each block represents audio with no pauses. The arrows beneath each block enable the user to recognise each block. The users are able to access a particular piece of audio by selecting its block. (How the users know which block to select is not clear.) This enables the user to review a specific aspect of the slide if they wish to, rather than forcing the user to listen to the entire audio file for each slide.

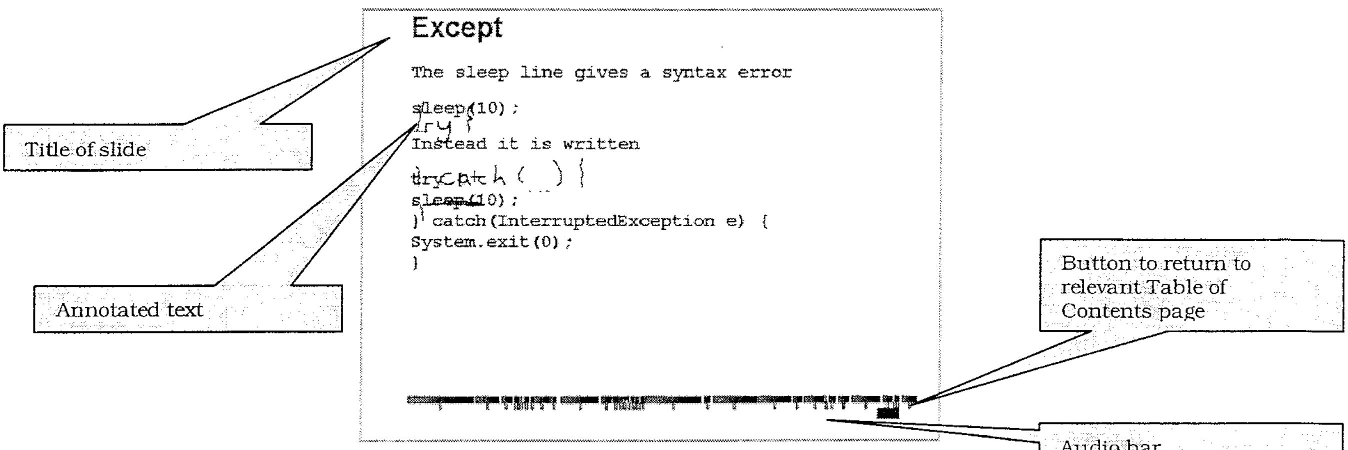



*Figure 2.10 Another example slide from the review tool.*

To return to the previous slide or go on to the next slide the user must first return to the appropriate table of contents page. The user is able to do so by selecting the blue ToC (Table of Contents) button usually found towards the end of the audio bar.

## 2.5 The Shadow Technology

To better support awareness of the presenter's movements during distributed activities, the LIDS Research Project have incorporated an on-screen shadow. A small camera, which sits in front of and facing the screen and the presenter, is used to capture the outline of the presenter. This outline, which is then filled in with gray, then becomes part of the image that the other distributed party sees.

## 2.6 Summary

The LIDS Research Project have constructed their own LIDS screens that are used in conjunction with rear-computer projection. The Mimio™ digitiser sits on one side of the screen and captures the presenter's on-screen movements. These movements include interactive gestures that are used to explore the presentation or record annotations. On-screen movements and explorations are performed with a pen-like device. Off-screen user movements can be recorded and seen as a shadow on the screen. The presentation is able to be stored and made available for on-line review after the presentation.

# 3. Technology in Use for Teachers and Students (Usability Study 1)

The main purpose of the Technology in Use for Teachers and Students study was to explore the collaboration support for an interactive group within a classroom situation where LIDS was used as the predominant information display and interaction medium. The study was used to determine whether the technology adequately supported the information gathering and presentation needs of both the teacher and the students, and whether this media enabled adequate learning both within the classroom situation and outside of the class environment.

## 3.1 Summary

**Summary:** *Our usability study of LIDS in use as a presentation and learning support tool for a lecture situation found that in general the participants viewed the technology positively. They indicated that it was as good as, if not better, than other more traditional or better-known presentation media i.e. blackboard, whiteboard, OHP or Powerpoint™. The participants also liked being able to review material online after the lecture as it allowed them to reinforce or improve upon what they had learnt in class.*

Millions of group meetings and presentations (e.g. business group meetings, research group meetings, lectures) take place around the world daily. These collaborative events are generally held in real-time and in one place (although video- and tele- conferencing is becoming more popular for supporting distributed meetings). The material for a meeting will typically be presented with large display screens such as whiteboards, blackboards, OHPs and Powerpoint™ on a computer, all which enable the presenter to share a visual space with the audience.

Meetings or presentations are typically dynamic events that generate much content and many ideas. Productivity is usually encouraged by transparency of collaboration and spontaneity in presentation, where material (which may be prepared in advance) must be allowed to alter and evolve in correspondence to the meeting. The presentation media itself must be adaptable and flexible, easy to interact with and easy to make changes on the fly while enabling the presenter to effectively engage the audience. Further, it is desirable for the audience to be able to review the material in a way that takes into account the transparency and evolution of the meeting.

Despite these needs, today's range of presentation media is usually limited in many of these requirements. For example, making changes on the fly can be relatively easy for white- and black-boards, but these medias tend to be less flexible and do not provide good after-meeting material support. Powerpoint™, although more flexible and provides good after-meeting material support, is difficult to change on the fly—the presenter is forced to disengage from the audience in order to manipulate the computer mouse or keyboard.

**The Large Interactive Display Screen**

The LIDS Research Project have developed a low-cost large display surface that is used with surface digitising and computer projection, and that has been designed to support many of the presentation requirements suggested above. It can be used in a similar way to a white- or black- board where the presenter starts with a blank screen, or it can be used with materials prepared in advance. Further, it enables group members to review meeting materials online.

### Testing the Large Interactive Display Surface for Meeting Support

To find how well the LIDS (as developed by the LIDS Research Project) met the other requirements of transparency, spontaneity, adaptability, flexibility and ease of interaction, we put the LIDS to use in a typical lecture situation.

We observed the lecturer (presenter) presenting lectures over three separate sessions. During the first sessions LIDS was not used; the remaining sessions used the LIDS. We also surveyed the students about their within-class and out of class support provided by the LIDS technology.

### Usability Problems (In Brief)

Several usability problems caused difficulties for the students in our study:

*The Presentation Tool*

- **Poor visibility and readability** of on-screen material, **incorrect slide sizing** and **technical instability** meant that the students focused on LIDS as a technology rather than the task at hand and the associated collaboration.
- **Distracting on-screen icons** e.g. the pencil image caused the students to become side-tracked from the on-screen material.

*The Presentation Review Tool*

- **Technical issues**, such as slow download times, poor audio quality and unclear video meant that the students focused on the technical aspects of the online application rather than the material that they wished to review.
- **Unclear association between annotations and prepared materials** caused some confusion.
- A **lack of the presenter's image** meant that the students found the personal aspect of the review tool to be lacking. (This is an important aspect of any collaborative tool.)

Our usability findings indicate that the technical instability of the LIDS software for presentation and review is the first priority to solve before focusing on other features that could be improved upon. The problem is that a 'breakdown' occurs, where the users are forced to focus on the technology rather than their tasks or the collaboration that takes place.

### Usability Benefits (In Brief)

Although the students experienced major technical difficulties while using LIDS, they were able to recognise the many benefits that its use could bring them:

*The Presentation Tool*

- **Better collaboration between students and lecturer**, as student-initiated discussion, additional notes and/or highlights, and further clarifications or explanation could be directly incorporated into the presentation material.
- **Ability to distinguish important or highlighted material** through the use of annotations and hand-written notes.
- **Added flexibility** where prepared materials are used but added or modified as required.

*The Presentation Review Tool*

- **Reinforcement of material** covered in the lecture, which enabled some students to learn extra beyond what they had observed in class and helped some students to clarify concepts that they had not fully understood previously.

- **Access to missed material**, which allowed some students to hear things missed or forgotten from the lecture.

- **Flexibility of review**, where the students could review the material in their own time and at their own place, and to review either the entire or parts of the presentation.

For this study, most students could understand the utility of LIDS when used in a lecture situation and when used as a review tool. Most said that they would use the facility if it was made permanently available.

#### LIDS as a Meeting Support Tool

In broader terms, for meeting support the LIDS tool provides good and spontaneous collaboration between the presenter and the audience, enables important information to be easily highlighted or missing information easily added in a transparent and flexible way that reflects the evolution of the meeting, and provides the ability for the audience to review the material at their own pace where they may also pick up on missed points and clarify points brought up during the meeting.

## 3.2 Study Organisation

#### Objectives

This was primarily an exploratory study of the use of LIDS in a teaching situation, used to determine the effectiveness of LIDS and its acceptability by both teachers and students.

#### Problem Statement

The specific questions that were to be answered during this study are:

1. How effective is the LIDS technology in supporting the needs of a classroom teaching situation?
2. How accepted is the LIDS technology in supporting the needs of a classroom teaching situation?
3. Does the technology adequately support the teaching and learning styles and requirements of the users?
4. Does the technology adequately enable information to be gathered and presented?
5. What are the longer-term effects of the LIDS technology i.e. from one lecture to the next, and from one group to the next?

#### Procedural Notes

The study consisted of four sessions, three where a series of lectures for the paper 0657.209S, Object Oriented Programming (a second year summer school paper) were observed and one a follow-up session. Mr Bill Rogers was the lecturer for this paper.

The first three sessions of the study were conducted over three consecutive lectures (held over three days) during the third week of lectures. The number of students (the participants for this study) varied over these three lectures.

*Session 1*

The first session/lecture was one hour in duration. This was a standard lecture presentation. Powerpoint™ was used as the predominant presentation medium. Some sample program files were shown. A lecture handout was also provided by the lecturer. The LIDS screen (a large piece of glass with thick draughting paper attached to the back of the glass) was used with rear-projection as the projection screen to display the Powerpoint™ presentation and to display the programs that were run. The lecturer wrote on the LIDS screen with a standard whiteboard pen. The pen markings were erased from the LIDS screen with a whiteboard duster. The whiteboard in the room was also used to write on.

At the beginning of the first session, the participants were given a brief overview of the purpose of the study and were asked to fill in an initial questionnaire. The questions in this questionnaire related to the participants' demographic information and their previous learning experiences in the classroom environment. The main part of the session consisted of lecture delivery. The first session concluded with a summary questionnaire about the participants' experiences with the lecture.

*Session 2*

The second session/lecture was two hours in duration and consisted of a prepared Powerpoint™ presentation delivered using the LIDS technology (the LIDS screen, Mimio™ digitiser, Mimeo™ pen, computer and projector). A lecture handout was referred to during the lecture. At the beginning of the lecture, the lecturer ran a program (on his own computer) which he projected onto the LIDS screen. During the lecture, the lecturer was able to move from slide to slide using the LIDS pen and gestures recognised by the LIDS software. The lecturer added notes (annotated) the Powerpoint™ presentation during the lecture. He did so by writing on the LIDS screen with the Mimeo™ pen. The annotations were saved by the LIDS software as part of the presentation. The lecturer wore a headset and his speech was saved to file as part of the lecture presentation.

At the beginning of the second session the participants were asked to fill in an initial questionnaire. The questions in the initial questionnaire related to the participants' experiences with reviewing the material delivered in the first session/lecture. The main part of the session consisted of lecture delivery. The second session concluded with a summary questionnaire about the participants' experiences with the lecture.

*Session 3*

The third session/lecture was one hour in duration and was intended to be delivered using the LIDS technology. It began with a prepared Powerpoint™ presentation. However, nearly halfway through the lecture problems were experienced with the LIDS software. At this point the Powerpoint™ presentation was abandoned, and was replaced by a standard lecture format. The projector was turned off and the lecturer continued the lecture using the LIDS screen as a whiteboard.

At the beginning of the third session the participants were asked to fill in an initial questionnaire. The questions included in this initial questionnaire for the third session related to the participants' experiences with reviewing the material delivered in the second session/lecture. The main part of the session consisted of lecture delivery. The third session concluded with a summary questionnaire about the participants' experiences with the lecture.

*Follow-Up Session*

The participants were asked to complete two follow-up questionnaires during the Monday lecture in the week following the first three sessions. The first questionnaire (initial questionnaire) asked participants about their experiences using the LIDS technology to review the material delivered in the first LIDS lecture (session 2). The second questionnaire (summary questionnaire) asked participants about their experiences and feelings regarding the LIDS technology as an educational tool.

### Test Environment and Equipment Used

The study was conducted in G1.15, the group user room (and Department of Computer Science seminar room), which was specifically set up to accommodate a lecture with the LIDS screen situated at the front of the room (see Figure 3.1).

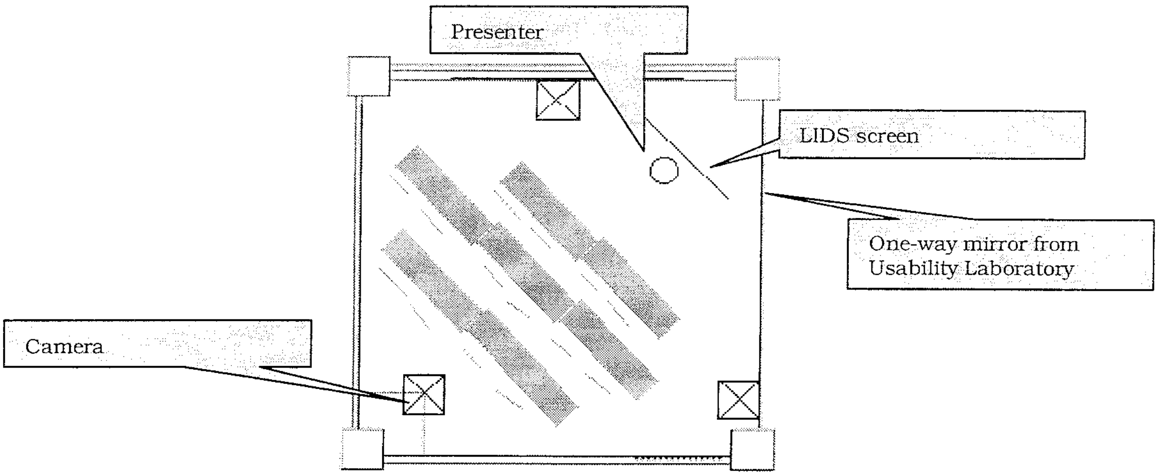



*Figure 3.1 Layout of group user room for study.*

Three cameras (represented as 'X' in a box in Figure 3.1, above) were placed for observation during the sessions. One camera was positions to view the LIDS screen from directly in front of the screen; the other two cameras were positioned at an angle in front and to either side of the LIDS screen.

A scan converter was connected to the projector in order to collect a fourth image, the output from the computer, enabling the image from the screen to be recorded onto video.

A four-quadrant mixer was used to combine the four images, which were then arranged to display the LIDS screen in the top left-hand corner, the camera image of the screen from the left (facing the screen) in the top right-hand corner, the camera image of the screen from the right (facing the screen) in the bottom left-hand corner and the image from directly in front of the screen in the bottom right-hand corner (see Figure 3.2).

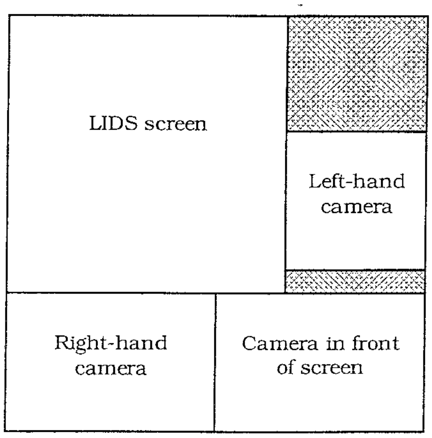



*Figure 3.2 Layout of the four-quadrant mixer.*

**Data Collection**

Data was collected using the eight questionnaires (described above) and through observation. The observations involved taking notes during each session and then while reviewing the recordings of each session.

**Participant Mix**

A large number of participants were used for this study. The number of participants for each session and their age range, and gender breakdown are listed below. The participants had on average 10 years computer experience, using a computer one to three hours per day. Nineteen had whiteboard experience, two did not.

| *Session* | *Number of Students* | *Age (range)* | *Gender (breakdown)* |
|---|---|---|---|
| 1* | 21 | 19-40 | 8 females; 13 males |
| 2** | 24 | 20-40 | 7 females; 13 males |

* For session 1, 1 participant did not give his age.

** For session 2, 4 participants, who did not complete the initial questionnaire in session 1, gave only their student ID number.

Session 3: For session 3, information for 6 participants did not exist, so we regarded the presentation of data invalid.

Session 4: For session 4, 2 participants gave their ID but hadn't filled in the initial questionnaire; another 2 did not give their ID numbers. The participant breakdown for this session has no bearing on the results.

*Table 3.1 Participant mix for usability study 1.*

## 3.3 Study Results

The results from the study are given below. Usability problems are discussed first, followed by usability benefits.

**Usability Problems**

The usability problems that were identified during this study can be categorised as (i) breakdowns, that is problems that forced the participants to focus on the LIDS technology rather than the task of learning and (ii) inhibitors/distractors, that is problems that inhibited or distracted the participants from the task of learning.

*Breakdowns*

Breakdowns occurred with both the presentation and presentation review tools.

*The Presentation Tool*

During the presentations, slides were incorrectly sized in relation to the screen and the navigation between the slides was slow. Further, the LIDS presentation software was unstable, crashing a number of times and, during the third session, forcing the lecturer to return to a more traditional presentation style i.e. using LIDS as a whiteboard.

*The Presentation Review Tool*

The presentation review tool was slow to download, disassociated annotations with the relevant content, and also had poor audio quality and unclear video quality in many cases. The problems with the audio included: no audio in the laboratories in R-block, the audio bars had no sound, words were missing from the commentary and some audio clips finished part way through a sentence.

These breakdowns forced the participants to focus on the technology rather than the task of learning. These issues are the most critical and should be the initial focus during ongoing development. These are technical rather than usability problems. As such, these are not discussed further in this report.

*Distractions*

During the presentation, the participants found the screen difficult to read from. Depending on the participant's position and angle in relation to the screen, a participant may have found the screen to be blurry, difficult to see/read from, or highly reflective. Although associated with the usability of LIDS, these problems are more to do with the LIDS construction and are beyond our scope; as such they are not discussed further in this report.

Other usability distractions also existed. These are discussed in more detail below.

*The Presentation Tool: Pencil Image*

- **Relevant Usability Principle**: Aesthetic and Minimalist Design.
- When the presenter draws/annotates on the screen, the LIDS software indicates the position of the pen on the screen with a pencil image (shown in Figure 3.3).

*Figure 3.3 Existing pen image on the LIDS screen.*

However, some (two) participants found the image distracting as it covered up existing text.

*"Pencil on screen annoying, covers [text] up."*
*"Might try to get the pencil on the screen out of the way."*

We suggest that although only two participants commented on this issue, that it is a valid usability problem.

- **Design Recommendation**: We recommend that the pencil image be replace with a simple cross (see Figure 3.4) with the centre of the cross corresponding to the tip of the pen when placed on the screen. This should minimise the graphics used and cause existing text that originally sat behind the image to be viewable.

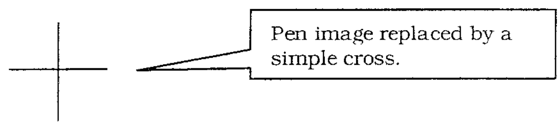



*Figure 3.4 Suggested replacement pen image for the LIDS screen.*

*The Presentation Tool: The Delete Gesture*

- **Relevant Usability Principle**: Error Prevention.
- The lecturer showed some difficulty with using the delete gesture (the zigzag motion from bottom to top) more than once during the presentation. For each time he had a difficulty, the lecturer had to attempt the delete gesture several times before it worked. Towards the end of

the presentation, he reverted to using a simple 'x' to cross out the mistake. This meant the mistake was left on the screen.

- **Design Recommendation**: We recommend that the delete gesture be changed to something more intuitive. See the section on the Interactive Gesture Recognition Tools for further details.

*The Presentation Review Tool: Video of Presenter*

- **Relevant Usability Principle**: Missing Feature.
- The presenter's image is not present in the review tool. This can lead to a lack of presence and awareness, both important elements of a collaborative tool.
- **Design Recommendation**: We recommend that where able the presenter's image should be recorded throughout the presentation and then incorporated within the review tool. The image does not need to be large (see Figure 3.5), and the position of the image within the slides could be determined by the presenter before putting the material online.

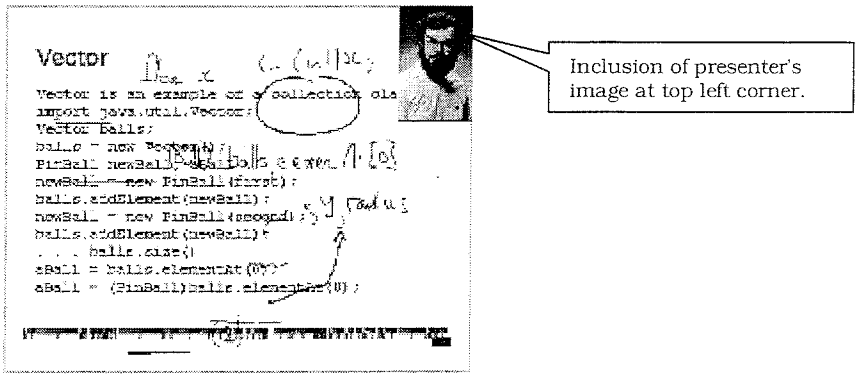



*Figure 3.5 Inclusion of the image of presenter within the Presentation Review Tool.*

*The Presentation Review Tool: Audio Bar*

- **Relevant Usability Principle**: Simple and Natural Dialogue.
- The participants found the separate audio blocks tedious and unnatural.

> *"When I press the sound files, it executes but not continuously. So I have to press again. I don't feel good about that."*
>
> *"Tedious clicking on different audio sections then waiting to download."*
>
> *"Splitting up the [audio] breaks the continuity and made it hard for me to maintain concentration."*
>
> *"Having separate sound clips, then it is hard to access each bit."*

- ***Design Recommendation:*** This issues is discussed in more detail in the Presentation and Use of Audio Bar section of section 6 of this report.

### Usability Benefits

The usability benefits that were identified during this study can be categorised as (i) usefulness for annotations, (ii) integration of material, (iii) presentation facilitation, (iv) flexibility in presentation, (v) accessed to missed material, and (vi) reinforcement of material covered during presentation.

*The Presentation Tool: Usefulness for Annotations*

Seven participants commented on the usefulness of the ability to annotate notes to an existing presentation. Comments include:

> *"Hand written notes useful to jot down as notes [in own lecture notes]."*
>
> *"It helped because the lecturer could add extra text to explain the notes."*
>
> *"Because the teacher can explain more."*
>
> *"Student could ask a question and lecturer could integrate this into the notes."*
>
> *"It can highlight important stuff."*

*The Presentation Tool: Integration of Material*

Eight participants noted the benefit of having the presentation material integrated in the one media/location:

> *"Only one piece of equipment to focus on, which makes [the lecture] easy to follow."*
>
> *"All notes in the same places."*
>
> *"It's not much different to a normal lecture presentation, it's just more concentrated at one point (one board)."*
>
> *"Easy to follow because writing on same screen."*
>
> *"Powerpoint and hand written notes a good combination."*
>
> *"Same screen: no other stuff than Powerpoint and handwriting."*
>
> *"Able to see how the notes and "whiteboard" marking interacted."*
>
> *"Not distracted by change from one media to another."*

*The Presentation Tool: Presentation Facilitation*

Three participants indicated that the LIDS presentation tool helped facilitate the in-class teaching:

> *"The LIDS technology aided the lecturer's teaching of the material."*
>
> *"A natural, convenient way to present."*
>
> *"Visual aid was clear and easy to use."*

*The Presentation Tool: Flexibility in Presentation*

Two participants found the LIDS presentation tool to be flexible:

> *"More flexible..."*
>
> *"It is easy to use, erase, go ahead. It will save time, so it will help me understand material better."*

*The Presentation Review Tool: Access to Missed Material*

Seven participants commented on the ability to access material missed during the presentation. Their comments included:

> *"I may have missed something and need to review it."*
>
> *"I can hear some missed important point again."*
>
> *"In a lecture, there is only so many notes I can take. I always end up missing something I really need to know about. I can get the stuff missed in lectures."*
>
> *"Sometimes I lose concentration in class, thus it is good to be able to go back and have a look."*

> *"I could hear things spoken that I may have missed the first time round."*
> *"Gave some clarification of concepts I missed during the lecture."*
> *"Some times you forget some thing important that was said, and now I could go back and listen again."*

*The Presentation Review Tool: Reinforcement of Material Covered During Presentation*

Similarly, three participants indicated that the presentation review tool helped reinforce material covered during the lecture:

> *"Listening to the explanation several times helped me to understand material better."*
> *"I understood concepts a lot better than I did after the lecture."*
> *"It was good to hear parts of the lecture again, as it reinforced ideas."*

## 3.4 Results in General

Analogous to other meeting/presentation environments, a lecture teaching situation is likely to be a dynamic event that generates much content and the exchange of ideas. Thus, a tool that enables this spontaneity to be captured in a transparent manner would be very effective in supporting the character of the meeting. It seems that the LIDS presentation tool does this by enabling slides to be prepared in advance and then annotated by the presenter. Further, the ability for the audience to review the exact presentation after the presentation has taken place in a way that they can control makes LIDS every effective in its support of a lecture teaching situation.

The participants in this study could understand the utility value of LIDS—as a presentation tool and as a review tool. The participants found that the lecturer's ability to annotate the prepared slides valuable, and the integration of different media into one location useful. Further, their ability to access missed material while using the review tool meant that they caught up or reinforced their learning. Most of the participants indicated that given the opportunity they would use the technology in the future.

# 4. Interactive Gesture Recognition Tools (Usability Study 2)

The main purpose of the Interactive Gesture Recognition Tools study was to explore the use of the interactive gesture recognition tools (to explore and manipulate) by users when using Powerpoint™ on LIDS. The study endeavoured to learn from the participants the ease or difficulty they had using the gestures.

## 4.1 Summary

***Summary:*** *Our usability study of the LIDS interactive gesture recognition tools established that most participants found that all of the gestures except the delete gesture easy to use, simple and reliable. The delete gesture proved to be a problem for most participants. All the participants indicated that they enjoyed using the LIDS technology and the gesture recognition tools to perform their presentations.*

In today's working environment, computer users no longer work at only one machine. Instead, it is likely that people will have desktop computer, a laptop and even a PDA. Further, much of today's work is performed collaboratively, where groups of people (who may or may not be in the same place) work towards the completion of some shared goal and usually with the use of shared artefacts. Thus, the need to openly share and discuss one's work is a major requirement in today's work environment.

Typically, group meetings are held with the support of some large shared space (e.g. a whiteboard) that is used for the generation of concepts and the recording of ideas. Those spaces that are most successful encourage productivity by enabling collaboration to be transparent and spontaneous, supporting the need for adaptability and flexibility. The standard computer does not support these needs.

Whiteboards enable users (the presenter and audience) to see what is being done by other users while it is being done and every one can contribute to the material. This is a WYSIWYD—What You See Is What You Do—environment.

Unfortunately, the traditional whiteboard has its limitations—you can not print from it (so that the material can be reviewed after the discussions) and it can not share material with other mediums (i.e. PDAs, laptops and PCs).

**The Large Interactive Display Screen**

The LIDS Research Project has developed a low-cost large display surface that is used with surface digitising and rear-computer projection. Essentially it is a computerised whiteboard. Interactions are recorded as they occur and are stored on the computer for later retrieval.

**Testing the LIDS Interactive Gesture Recognition Tools**

To discover how well LIDS supported the WYSIWYD paradigm, we observed six participants as they told us a story while using the interactive gestures on the large surface. We also surveyed the participants about their experiences with the interactive gestures and the LIDS technology in general.

**Usability Problems (In Brief)**

Several usability problems caused difficulties for the participants during our study. These problems are pervasive with all the gestures (and particularly the delete gesture) and interaction mechanisms.

- **Gestures drawn incorrectly** whether by **using the wrong shape** or **loosing pen contact with the screen** meant that the gestures were not recognised by the LIDS software and remained on the screen as if part of the presentation material. A **lack of an easy undo mechanism** meant that in most instances the participants left the unwanted gesture on the screen while navigating to a next or previous slide, or in the case of the delete gesture had to use it multiple times and/or revert to the erase all gesture.

- **Lack of clear indication when software was not in a 'ready' state/mode** (i.e. the software was still saving or the LIDS pen was not ready), which meant that users had to repeat a gesture when the software became 'ready'.

- **Collisions with unintentional gestures** meant that the software acted in an unwanted and surprising manner.

- **On-screen software options were not consistently viewable** confusing some participants.

- **Incorrect registration and difficult readability of on-screen text** restricted some participants in their tasks causing them to become frustrated.

- **Lack of interactive options** (e.g. copy and paste options) also restricted material used by the participants during their presentations.

The existence of these problems indicates the occurrence of 'breakdowns', where the users are forced to focus on the technology rather than their tasks or the collaboration that takes place.

**Usability Benefits (In Brief)**

Although the students experienced some difficulties while using gestures on LIDS, they were able to recognise the many benefits using LIDS could bring them:

- Once learned, the gestures are **easy and simple to use**.

- The **gestures are low in complexity**.

- The mapping between the gestures and actions are **simple to understand**.

- The **actions are natural** and similar to using pen and paper.

For this study, most participants enjoyed being able to give a presentation in a flexible and spontaneous manner. They found the gestures natural, easy to use and simple to understand which added to their enjoyment of the LIDS product.

**LIDS as a WYSIWYD**

In broader terms for meeting support, the LIDS tool provides for flexible and spontaneous collaboration between the users. The WYSIWYD environment means that interaction is more transparent and the need for complicated menu systems is minimised.

However, the question of whether some of the gestures adequately support the WYSIWYD whiteboard paradigm still remains. These actions are not normal to a whiteboard situation. For example, to remove the material off the whiteboard a whiteboard duster is used instead of a zigzag over the material to be removed. Further, the gestures are unintentionally simulated by the users at times and the participants commented on the need for more on-screen options to simplify the use of LIDS.

## 4.2 Study Organisation

### Objectives

This was primarily an exploratory study of the use of the interactive gesture recognition tools when used with PowerPoint™ on LIDS. The study was used to measure the effectiveness of the gesture recognition tools as a way of navigating through a PowerPoint™ presentation, and performing graffiti such as cross-outs, underlines, inserts, arrows and so on. The study was used to determine ways of improving the gesture recognition tools for use with LIDS.

### Problem Statement

The specific questions that were to be answered during this study are:

1. How effective are the interactive gesture recognition tools in enabling users to navigate, draw and edit a PowerPoint presentation?
2. In general, how do the users feel about the gesture recognition tools?
3. Do they take long to get used to it?
4. In general, do the users find the gesture recognition tools a help or a hindrance while they perform their tasks?
5. At which points do the users find the gesture recognition tools a help? At which points do the users find the gesture recognition tools a hindrance?

### Procedural Notes

Each session began with an initial questionnaire in which the participants were asked questions relating to demographic information and their experiences using Powerpoint™. It was followed by a brief training session using LIDS and the gesture recognition tools. The main part of the session involved the participants creating a Powerpoint™ presentation using LIDS and the gesture recognition tools. Each participant presented a story, similar to that of Goldilocks and the Three Bears, incorporating both text and images in their presentation. A drawing of the gestures, which the participants could refer to, was displayed on a whiteboard throughout the session. The participants were not given a time limit although they were expected to finish within a given time.

### Test Environment and Equipment Used

The study was conducted in G1.15, the group user room (and Department of Computer Science seminar room), which was specifically set up to accommodate the LIDS screen situated at the front of the room (see Figure 4.1).

Three cameras (represented as 'X' in a box in Figure 4.1, above) were placed for observation during the sessions. One camera was positions to view the LIDS screen from directly in front of the screen; the other two cameras were positioned at an angle in front and to either side of the LIDS screen.

A scan converter was connected to the projector in order to collect a fourth image, the output from the computer, enabling the image from the screen to be recorded onto video.

A four-quadrant mixer was used to combine the four images, which were then arranged to display the LIDS screen in the top left-hand corner, the camera image of the screen from the left (facing the screen) in the top right-hand corner, the camera image of the screen from the right (facing the screen) in the bottom left-hand corner and the image from directly in front of the screen in the bottom right-hand corner (see Figure 4.2).

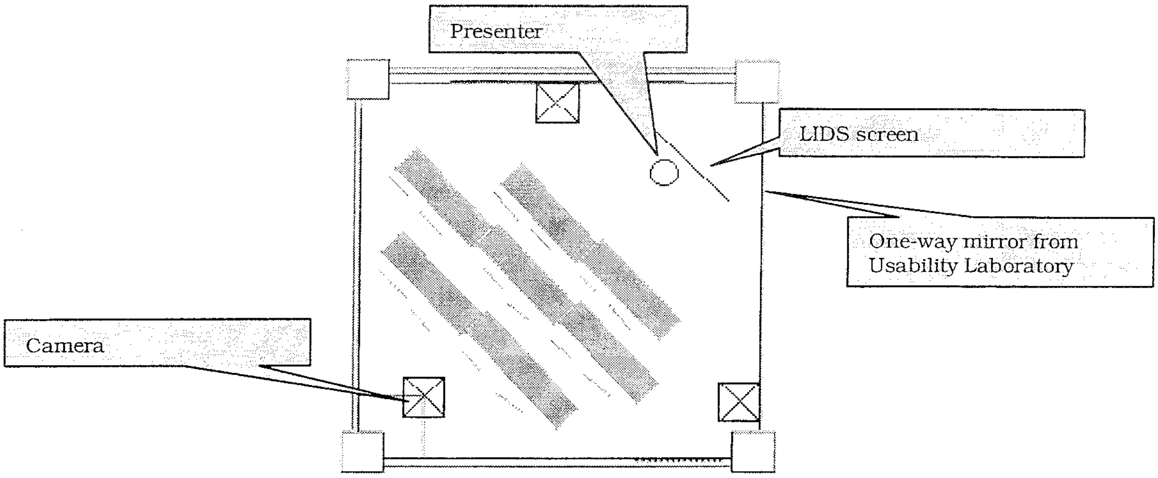



*Figure 4.1 Layout of group user room for study.*

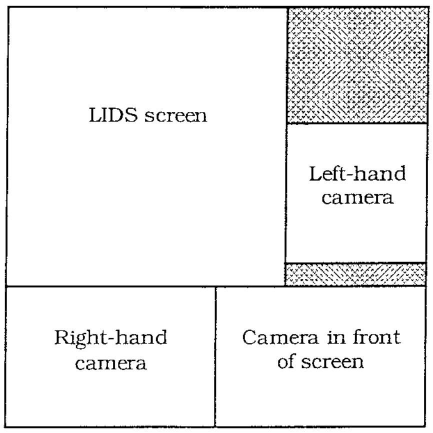



*Figure 4.2 Layout of the four-quadrant mixer.*

**Data Collection**

Data was collected from each session by using two questionnaires (an initial questionnaire and a summary questionnaire) and through observation. The initial questionnaire asked the participants questions relating to their demographic information and their previous experience using Powerpoint™. The summary questionnaire asked the participants questions relating to their experiences with LIDS and their use of the gestures. The observations involved taking notes during each session and then while reviewing the recordings of each session.

**Participant Mix**

Six participants were used for this study: three females and three males. The participant genders, ages, computer and Powerpoint™ experiences are listed below in Table 4.1.

Participants were students at the University of Waikato who were recruited by advertising posters displayed in various notice boards around the University campus.

| *Participant* | *Gender* | *Age* | *Computer experience* | *Powerpoint™ experience* |
|---|---|---|---|---|
| 1 | F | 36 | 23 years; 4-8 hours per day | Yes |
| 2 | M | 36 | 15 years; greater 8 hours per day | Yes |
| 3 | M | 31 | 14 years; greater 8 hours per day | Yes |
| 4 | F | 21 | 11 years; 1-3 hours per day | Yes |
| 5 | F | 31 | 13 years; 1-3 hours per day | Yes |
| 6 | M | 23 | 13 years; greater than 8 hours per day | Yes |

*Table 4.1 Participant mix for usability study 2.*

## 4.3 Study Results

The results from the study are given below. Usability problems are discussed first, followed by usability benefits.

**Usability Problems**

A number of usability problems were identified during this study. These issues include the gestures, on-screen options and on-screen readability.

*Next and Previous Gestures: Gestures Drawn Incorrectly Using the Wrong Shape*

- **Relevant Usability Principle**: Error Prevention; Flexibility and Efficiency of Use; User Control and Freedom.
- Four of the participants experienced problems while drawing the next slide and previous slide gestures as they used the wrong shapes. Problems occurred because of unusual or too large a shaped arrow head (see (i) in Figure 4.3), the line in the return direction being too short (see (ii) in Figure 4.3), and the main horizontal line being too curved (see (iii) in Figure 4.3).

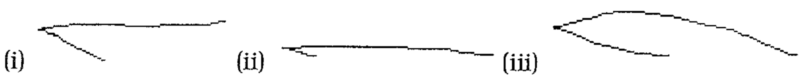



*Figure 4.3 Examples of problems with the next and previous slide gestures. Problems included (i) too large a shaped arrow head, (ii) the line in the return direction being too short, and (iii) the main horizontal line being too curved.*

As noted by some of the participants:

> *"It was the line thing. When I do that line, if I didn't come back far enough, I just end up with a line...I had to make sure I came back to there* [pointing to about half way]*...You can't go back too far either. It was generally not going back far enough in the reverse direction." (P6)*
>
> *"They require a steady hand to draw the straight line." (P4)*

The learning curve was relatively high for some participants. Some took up to fifteen times before they were able to complete the gesture successfully the first time. Others had to try it two or three times per time.

Problems also occurred, as the next and previous slide gestures, if drawn unsuccessfully, remained on the screen as unrecognised gestures or unintentional drawing by the user. Frequently, the participants left the unrecognised gestures on the slide as they went to the next or previous slide, which meant that unwanted strokes remained.

- **Design Recommendation**: We offer a range of recommendations.

  1. Provide a separate training module where each of the gestures is pre-drawn (similar to those that were drawn on the whiteboard for the training part for each session) and the user over-draws the gestures, mimicking the size and shape of each gesture as it is pre-drawn on the slide. This offers users with the ability to train and practice at any time. Further the users have an on-line reference from which they can determine the right size and shapes to use. To access this module a separate help ('?') button should be added to the screen (perhaps in one of the bottom corners, see (i) in Figure 4.4) which, when accessed pops up a separate window containing the training module (see (ii) in Figure 4.4).

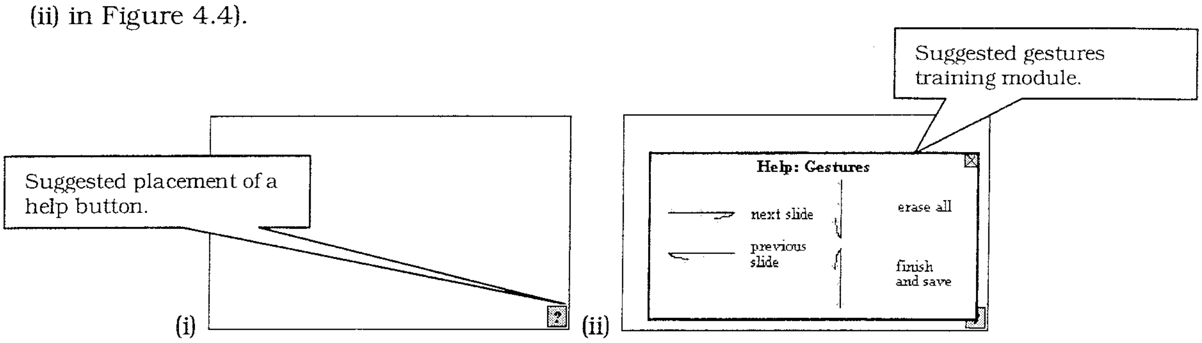



*Figure 4.4 Suggested separate training module (see (ii) above), accessible from a help button on screen (see (i) above).*

  2. Provide users with the choice of having navigational (i.e. next and previous slide) buttons on-screen. (A suitable location for these might be at the bottom centre of the screen (see Figure 4.5).

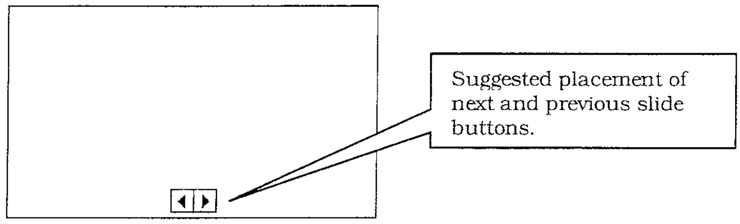



*Figure 4.5 Suggested placement of next and previous slide buttons on the screen.*

  Having the buttons located here, rather than on the left- or right- hand side of the screen means that the user does not have to reach to one side of the screen to access the buttons. It also means that the users are not forced into using the gestures, if they do not wish to.

  Unfortunately, it will mean that the users will need to take the existence and placement of the buttons into account when preparing their presentations and that additional use of the screen (e.g. for annotations) will be restricted to a slightly smaller area. Further, the users may need to move to a position more suitable for using the buttons whenever they wish to move to the previous or the next slides.

  3. Set an area of the screen, say the bottom of the screen, aside for drawing gestures (see Figure 4.6).

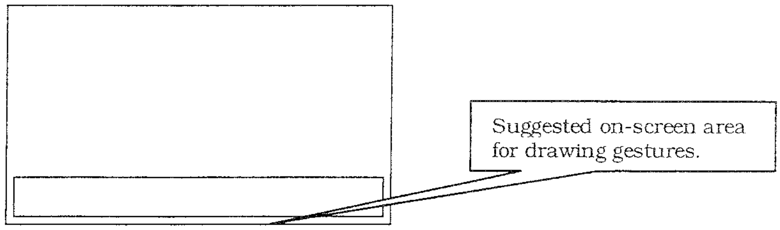



*Figure 4.6 Suggested placement of gesture drawing area on the screen.*

This could allow for a little more flexibility for the users when they draw a gesture. For example, if they draw a next or previous slide gesture with a too large a shaped arrowhead the software should recognise it properly.

Unfortunately, this will mean that the users will need to take the gestures area into account when preparing their presentations and that additional use of the screen (e.g. for annotations) will be restricted to a smaller area. Further, the users may need to move to a position more suitable for using this area whenever they wish to use a gesture.

4. Provide an undo (and possibly redo) gesture (or button, if implemented) to remove unsuccessful strokes. This means that the user can remove unrecognised and unwanted strokes from the slide, minimising the clutter on the slide.

   The suggested gestures (for undo see (i); for redo see (ii)) are given below in Figure 4.7.

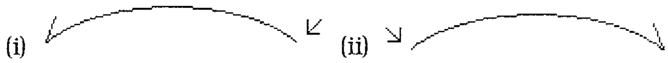



*Figure 4.7 Suggested undo (see (i) above) and redo (see (ii) above) gestures. The arrows are used to indicate where the gestures should start.*

*Next and Previous Gestures: Gestures Drawn Incorrectly As Software Was Not Ready*

- **Relevant Usability Principle**: Visibility of System Status.
- Most participants experienced problems drawing the next (two participants) and previous (four participants) gestures due to the LIDS software not being ready. The participants started to use the gesture while the software was not in a 'ready' state or mode. Although the interface does indicate the change in mode with an hour-glass in the centre of the screen, it does not make the change in mode clear enough to the users. This meant that the participants had to redraw the gesture once the software was ready, a redundancy in use.
- **Design Recommendation**: We recommend that modes should be explicitly recognised in the interface design. The different states ('ready' and 'not ready') should be indicated more clearly and distinctly in feedback to the users. Thus, it is less likely that the users will experience problems while the system is in a 'not ready' state. One way of achieving this is to add different sound effects. Another way is to change the colour of the windows.

*The Delete Gesture*

- **Relevant Usability Principle**: Error Prevention; Flexibility and Efficiency of Use; User Control and Freedom
- All of the participants experienced problems with the delete gesture. The problems included the delete gesture:

i. Not being big enough i.e. not fully covering the item to be deleted (this occurred 29 times, see (i) in Figure 4.8).

ii. Comprising four not five strokes (this occurred 26 times, see (ii) in Figure 4.8).

iii. Starting at the top rather than the bottom (this occurred eight times, see (iii) in Figure 4.8).

iv. Being too curved (this occurred five times, see (iv) in Figure 4.8).

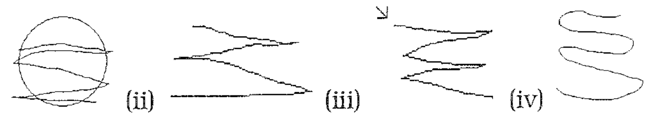



*Figure 4.8 Examples of problems with the delete gesture. Problems included the delete gesture (i) not being big enough to fully cover the item to be deleted, (ii) comprising four not five strokes, (iii) starting from the top (as indicated by arrow) rather than the bottom, and (iv) being too curved.*

Five of the six participants used the delete gesture successfully the first time in fewer than half of the instances in which it was used. In other words, for each time the delete gesture was used the participants had to attempt it more than once before they were successful. At the extreme, one participant (P5) attempted the delete gesture more than 20 times before it worked successfully.

Part of the problem involving the delete gesture is that if it is not successfully used the first time the unsuccessful gesture remains on the slide, producing a large mess. During our study, when this happened the participants then tried to remove the unsuccessful gesture by using another delete gesture. If this was not successful, then the participants were left with a large mess on the screen. As one participant put it:

> *"When it doesn't work, it gets progressively worse." (P5)*

At times during the study, this problem got so bad (and frustrating) that the participants either gave up or reverted to using the erase all gesture. One participant who had particular difficulties with the delete gesture said:

> *"For some reason I had difficulty getting the right number of strokes...it has to be all encompassing and it's easy to forget that. And it gets progressively worse." (P5)*

The participants experienced other difficulties when using the delete gesture.

- The gesture sometimes removed more material than was wanted. For example, one participant commented on not being able to remove just part of what had been drawn:

  > *"I can't just delete part of it, can I?" (P1)*

- The participants sometimes unintentionally simulated the gesture when trying to colour an object.

- The gesture does not remove material that has already been saved. For example, during the training session one participant tried using the delete gesture several times in succession to remove material. The gesture should have worked and this puzzled the participant until it was realised that the slide had been moved from and then back to.

In summary, the delete gesture is more complicated than the other gestures to use. As one participant noted:

> *"I found this going forwards and backwards very easy. This stroke [simulates the next and previous slide gestures in the air]...To erase something takes a bit more time to get used to. I just need to a bit more time to get used to it.' (P3)*

- **Design Recommendation**: We offer a range of recommendations.
  1. Make the software work with the Mimio™ eraser. This has two contact areas: a small and a large pad (see Figures 2.6 and 2.7). Using this tool would be more analogous to using a whiteboard duster. Further, the Mimio™ eraser can be developed and incorporated as part of the LIDS pen, so that it is more like a pencil i.e. writing point (lead) at one end and eraser at the other (see section 7 of this report).
  2. Incorporate an undo mechanism (see Figure 4.7), so that if the user erases a greater areas than is required, then the user can undo the last action and try again. This should provide users with added flexibility and control.
  3. Enable existing and saved material to be removed. Again, this should provide users with added flexibility and control.

*Difficult Readability of On-Screen User-Drawn Text*

- **Relevant Usability Principle**: Aesthetic and Minimalist Design; User Control and Freedom.
- Another aspect of the technology that the participants noted was the size of the on-screen user-drawn text and restrictions this presented in doing the task. At the beginning of the task, one participant (P6) remarked on the size of the writing produced by the pen on the screen.

  > *"You wouldn't want to write too much...or couldn't fit too much writing on there. Or I couldn't." (P6)*

  Another participant (P5) chose to write all of the text in the presentation in block case to improve the legibility of the writing.

  Some participants, when asked how the software could be improved, indicated the need for some form of hand writing recognition.

  > *"Text recognition."(P3)*
  >
  > *"Hand writing recognition and conversion to text." (P4)*

- **Design Recommendation**: We believe that the users' ability to annotate or write on the screen, directly where the text is to be placed with hand written text a significant benefit to the user. As noted in the Technology in Use for Teachers and Students study (see part 3 of this report), this meant that additions were highlighted against the prepared material focusing the users' work. Thus, to suggest that some form of hand writing recognition technology be adopted would work against that benefit. However, having the choice of which mode to work in would provide greater flexibility for the users.

  In terms of the problem with the size of the text, perhaps the issue could be at least partially improved by having better anti-aliasing.

*Incorrect Registration of On-Screen Text*

- **Relevant Usability Principle**: Consistency and Standards; User Control and Freedom.

- At one stage, one participant (P5) tried to draw a dot on the screen. This was not registered by the software. Instead, the participant had to use a small coloured-in circle in place of a dot.

  Two participants (P1 and P5) experienced difficulties trying to join lines that did not meet. As indicated by one participant:

  > *"I did actually find it quite hard...It doesn't flow easily as drawing images...The text was a little more difficult, but you have to remember to apply consistent pressure...otherwise you run into problems."* (P5)

- **Design Recommendation**: We are a little unsure as to what to recommend for this problem. Perhaps, the software could be a little more sensitive in what it recognises.

*Lack of Interactive Options*

- **Relevant Usability Principle**: Missing Features; User Control and Freedom.

- Some participants indicated that some useful interactive options were missing from the software. These included the ability to use a gesture for copying an existing slide and placing the content on a new slide:

  > *"Copy gesture, so that you can use same pictures and characters."* (P2)

  and the ability to return to the beginning of the presentation without having to first navigate all the in-between slides in the presentation:

  > *"Gesture to go back to the start."* (P4)

  This has implications for also including a gesture to go to the last slide directly, and perhaps even each individual slide.

- **Design Recommendation**: We recommend that the following features be incorporated into the software:

  1. A copy gesture that copies the existing drawing and text on a slide to the computer clipboard. This gesture can be extended so that users can select a portion (i.e. either a part or the whole) of the slide and copy this onto the clipboard. The suggested gestures are given below in (i.a) for entering the copy mode and (i.b) for selecting a portion of the screen of Figure 4.9.

  2. An insert gesture for manually inserting a slide after the current slide. The suggested gesture is given below in (ii) of Figure 4.9.

  3. A paste gesture that pastes what is currently on the computer clipboard onto the current slide. The suggested gesture is given below in (iii) of Figure 4.9.

  4. A gesture to enable the user to go directly to the first slide in the presentation. The suggested gesture is given below in (iv) of Figure 4.9.

  5. A gesture to enable the user to go directly to the last slide in the presentation. The suggested gesture is given below in (v) of Figure 4.9.

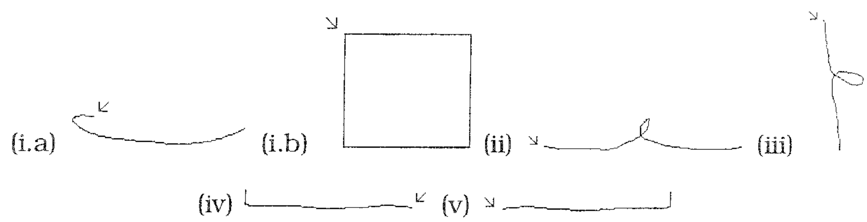



*Figure 4.9 Suggested gestures for (i.a) entering copy mode and (i.b) selecting the area to copy, (ii) for inserting a slide, (iii) for pasting the contents of the clipboard onto the current slide, (iv) for going to the first slide, and (v) for going to the last slide. The arrows are used to indicate where the gestures should start.*

If providing buttons at the bottom of the screen (as suggested for the next and previous slides above), then the actions i.a, ii, iii, iv, v should also be represented as buttons (see Figure 4.10). While the action i.a places the software in a copy mode, i.b should still be used as a gesture to select the area of the slide to copy.

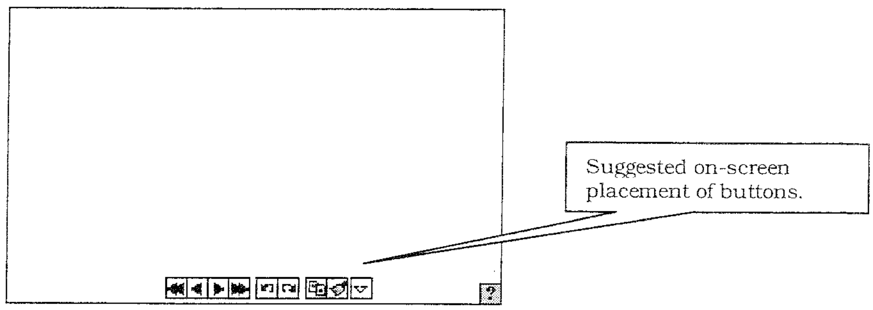



*Figure 4.10 Suggested buttons for first screen, previous screen, next screen, last screen, undo, redo, copy, paste and insert. The help button still remains in the bottom right corner.*

*Lack of Paint Tool-Type Options*

- **Relevant Usability Principle**: Missing Features.
- Some participants felt that to improve their presentation and therefore interaction with others they would like paint tool type options:

  *"Painting tools e.g. paintbrush with different sizes and colours." (P3)*
  *"Different brush sizes." (P4)*
  *"Fill tool for colouring." (P6)*

  One participant (P4) indicated that having more colours to select from would also be useful.
- **Design Recommendation**: We do not recommend that these suggestions be incorporated, as doing so diverges too much from the whiteboard paradigm.

***Technical Problems***

A few technical problems were experienced during the study. As they are technical problems that influence the usability of the product (rather than a design issue) we have not suggested any design recommendations.

*Finish and Save Gesture*

- A technical problem was noted by one participant (P6) while using the finish and save gesture. At the end of the task, he reviewed his presentation and added more drawing to an intermediate slide before using the finish and save gesture to exit the presentation. As the presentation closed, it appeared to remove the additional drawings he had done. When the presentation was reopened, the additional drawings had not been saved as part of the presentation. As the participant said:

> *"It's not finish and save, it's just finish." (P6)*

*Changing Pen Colour: On-Screen Start Button Sometimes Not Visible*

- Most (five) of the participants changed the colour of the pen during the study. Some (two) of the participants chose to change the colour of the pen multiple times. At times, the Start button, which incorporates the menu containing the options for changing the pen colour, was not visible on the screen. It seemed to appear and disappear at different times without any apparent pattern. This meant that the participants did not access the button, because they were not given the choice (they had no control) as it was not visible, or they had to take a guess as to where the button was located based on previous experiences.

**Usability Benefits**

The usability benefits that were identified during this study can be categorised as (i) LIDS easy and simple to use, and low in complexity, and (ii) gestures and actions are simple and natural.

*LIDS Easy and Simple to Use, and Low in Complexity*

The six participants could generally follow what was going on with ease. Four participants commented on the fast program response time and that no delays were experienced when writing on the LIDS screen. Five participants commented that the technology was simple to understand and relatively easy to use. One participant said that it was easier to use than other presentation packages she had used. Comments include:

> *"Immediate response" (P1)*
>
> *"Speedy, no significant delays."(P3)*

*Gesture and Actions Are Simple and Natural*

Although the participants experienced some difficulties with the gestures, by the end of the study five of the participants indicated that they found that it was easy to complete the task using the LIDS technology and the gesture recognition tools.

> *"...Initially have to focus on gestures. It does get progressively easier and far more enjoyable to use in the latter stages..." (P5)*

In particular, two participants commented favourably on the ease of using the LIDS technology and the gesture recognition tools to perform the task relative to other media. It was "like using paper and pen" and "easier than a whiteboard". Another participant liked being able to move from screen to screen without having to erase what had been written.

> *"Easy to use." (P5)*
>
> *"Ease of creating images." (P5)*
>
> *"Easy to create a story/presentation." (P5)*
>
> *"Relatively easy to change things."(P1)*

All six participants felt that the gestures were simple to learn and that most (excepting the delete gesture) were easy to use. One participant (P3) commented on their simplicity. Another participant (P6) commented on their being self-explanatory. Five of the participants felt that it was easy to navigate around Powerpoint™ using the next and previous slide gestures.

> *"Easy navigation—forward and back."* (P3)
> *"Forward/back is just a simple stroke."* (P3)
> *"Intuitive (left to go back, right to go forward)."* (P4)
> *"Very easy indeed; gestures for navigating through presentation easy to learn and use."* (P5)

Four participants felt that using the gestures did not inhibit their ability to complete the task. One participant said that it was as easy as using a pen.

All six participants felt that with use the gestures became easier to use. One participant commented on the relatively short learning curve associated with learning and using the gestures and the LIDS technology (about 15 minutes), after which time the participant felt that he was able to focus on the task rather than the technology (the gestures in this instance). Another participant said that he could easily do the gesture after about five minutes.

## 4.4 Results in General

In most instances, except when using the delete gesture, the participants found the gesture recognition tool effective for navigating their presentations. They found that using the LIDS screen with the Mimio™ pen a natural way of interacting with the media. However, they sometimes found when annotating their presentation that the size of their on-screen hand-written text was too large and somewhat difficult to read. Additionally, they found the delete gesture difficult to use and indicated a number of other gestures (i.e. copy, paste) that would be helpful for making a presentation on LIDS.

In general, the participants indicated that the gestures, although requiring a little time to learn to use, were natural, easily mapping to their concepts of the actions, simplistic and easy to use. Further, they found that incorporating the gestures as part of their presentations meant that they were able to present their material in a more seamless manner, thus they did not have to interrupt their working to use a keyboard or access complicated menu systems.

# 5. The Shadow Technology (Usability Study 3)

The main purpose of The Shadow Technology study was to assess the value the users placed on the shadow to support the awareness of, and interaction and communication with, other users working on the same task, but who were not in the same room.

## 5.1 Summary

**Summary:** *Our usability study of the LIDS shadow technology established that most of the participants were generally positive about the use of the shadow to support awareness of other users during collaborative activities. In comparison to using no shadow, the participants were confident with knowing what the other user was doing and collisions were less likely unless a breakdown in verbal communication also occurred. Surprisingly, the participants indicated that they were not confident that the other user was aware of what they were doing. Further, they suggested that their interaction and communication with the other user was not as good as working in the same room together or even working in two separate locations that had no shadow.*

In the past, meetings and collaborative activities have been conducted face-to-face or by using a telephone. Today, we see the emergence of many technologies designed to support collaborative activities. Some support collaborative activities that take place in the same room (co-located); others support collaborative activities that take place in different locations (distributed environments).

A successful collaboration involves the participants being able to share materials and artefacts easily, being aware of each other's presence and activities at all times, and being generally confident that the other participants are aware of what they are doing at all times. Further, it involves the feeling that every one works well together, that conflict is minimised, and that the group is able to achieve their goals and tasks in a relatively easy manner.

It is generally accepted that most meetings that take place within one room achieve these elements satisfactorily. But what about collaborative activities that take place within a distributed environment? One possible solution is to use video-conferencing, but this limits the sharing of materials and artefacts. Other collaborative tools that enable the sharing of material and artefacts (e.g. e-mail and on-line chat) do not support the users' need to be aware of others and have others be aware of them.

### The Large Interactive Display Screen

The LIDS Research Project has developed a low-cost large display screen that is used with surface digitising and rear-computer projection. This mechanism allows material and artefacts to be shared by more than one user at a time. Awareness of the other user (it has only been used in a two-way distributed environment) is achieved through the use of a 'shadow' of one of the users which is displayed on the other user's screen in real-time. The shadow is an outline of the user, filled with grey and which sits behind the text and other screen artefacts.

### Testing the LIDS Shadow Technology

To discover how well the shadow technology supports users within a distributed environment and how it compares to users being co-located (in the same room) or distributed but without the support of any shadow, we observed 12 groups of 2 participants as they performed 3 collaborative activities. The activity and environment mix were randomised for each group. We also surveyed the participants about their experiences with the different environments and the LIDS shadow technology in general.

### Usability Problems (In Brief)

Several problems caused difficulties during this study. These problems were technical in nature (i.e. **the system frequently crashed**) and should be solved first. During this study, **the shadow technology worked in only one direction** (rather than both). This meant that the participants did not experience as much of the shadow as they should. It also meant that we were unable to make quantitative measures, such as timing of tasks or the number of collisions of participants.

Several usability problems caused difficulties for the participants during our study. These included the perceived **low quality and unattractive effect of the shadow**, which the participants found distracting.

In comparison to working in a group in the same room, the participants indicated that they were:

- **A lot less confident that the other user was aware of what they were doing.**
- **Unable to follow what was going on with ease.**

*Note*: The participants found all these elements better than when compared against working in a group in a distributed environment but without any shadow support.

In comparison to working in a group in the same room or distributed but without any shadow support, the participants also indicated that:

- Their **group did not work well together.**
- They tended to **focus more on the technology** rather than their tasks.

These problems indicate that the technology needs to be improved somewhat so that users have more confidence with its use with LIDS within a distributed and collaborative situation.

### Usability Benefits (In Brief)

Although the participants had some usability problems with the shadow technology they still indicated that there were aspects of it that they enjoyed.

In general, the participants found:

- The shadow was **easy to use**—it was there, they did not have to manipulate it in any way.
- The concept of the shadow and what it represented was **easy to understand.**
- The shadow relatively was **friendly** and **reliable**—they could generally tell where the other user was standing and the other user's actions.
- The shadow was **likeable**—it didn't impede their work to such an extent that they were unable to achieve their tasks.

Further, the participants indicated that in comparison to working in a distributed environment but without the shadow technology:

- They were **aware of the other user**—where the other user was standing and what the other user was doing.

For this study, most participants were confident in their awareness of the other user (although not vice-a-versa) and the other user's actions. They found the concept of the shadow easy to understand and generally liked it.

### The Use of the Shadow to Support Distributed Work

In comparison to when the users worked in a distributed environment but without any support for participant awareness, the shadow helped the users to be more aware of the other users and what their actions were. However, the users did not seem totally confident with its use. This is most likely because of the perceived low quality and unattractive effect of the shadow, and because the breakdown of collaboration (resorting to competition in some of the sessions). Further, the participants found that they focused more on the shadow rather than on their tasks, and felt that they did not work as well together. This is perhaps because of the shadow technology's novelty value and the break down in verbal communication.

These results suggest that further thought needs to go into the use of the shadow and other ways that might better support the users' awareness of each other and better support the tasks that the users are trying to achieve.

## 5.2 Study Organisation

### Objectives

This was primarily an assessment study of the use of a shadow to provide awareness among the participants of a distributed collaborative activity while using LIDS. The study was used to inform the developers of the shadow technology of any issues associated with the use of the technology and LIDS that may impact on the effectiveness of the intended users' ability to interact and communicate with other users working on the same task but who will not be in the same room.

### Hypotheses

At the outset of this study, we aimed to conduct a proper experiment so that we could analyse the results rigorously. Unfortunately, due to technical difficulties we were unable to do so. Nevertheless, we have included the hypotheses as they have acted as general guides throughout the study.

The hypotheses for this study are:

1. The participants will collide less when using LIDS with the shadow.
2. The participants will be more comfortable (have a greater social awareness) while using LIDS with the shadow.

### Problem Statements

The specific questions that need to be answered are during this study:

1. How effective is the shadow technology in enabling distributed users to be aware of other interactive users?
2. How effective is the shadow technology in enabling the users to be aware of the other user's position in relation to the board?
3. How effective is the shadow technology in enabling the users to be aware of the other user's awareness in terms of the task?
4. In general, how do the users feel about the shadow technology?
5. Do they take a while to get used to it?
6. In general, do the users find the shadow technology a help or a hindrance while they perform their tasks?
7. At which points do the users find the shadow technology a help? At which points do the users find the shadow technology a hindrance?

**Procedural Notes**

The study consisted of 12 sessions with each session involving 2 participants.

Each session consisted of three tasks which were always performed in the same order. The tasks were aimed at an age level of around 10 years. The first task involved completing six short crosswords in which the participants had to enter a vowel (from a list of six options to complete all six crosswords) into the centre of four consonants arranged in a 'T' shape with a space at the centre to form two words when read left to right and top to bottom. The second task involved a word search of different dog breeds, comprising of a block of characters (x letters by x letters) at the top with a list of words to be found below (three columns each of x words). The third task consisted of 10 games of noughts and crosses ('0's and 'X's or 'tic-tac-toe').

The three tasks were performed under three scenarios each involving the use of a different technology. One scenario involved the two participants working together on the designated task in the same room on the same LIDS screen and sharing a pen (room A). We refer to this scenario as Non-Distributed (ND). Another scenario involved the two participants working together on the designated task in two separate rooms (rooms A and B), each with a LIDS and a pen. They had audio contact. We refer to this scenario as Distributed with No Shadow (DNS). The other scenario involved the two participants working together on the designated task in two separate rooms (rooms A and B), each with a LIDS and a pen. They had audio contact. In addition, the user in room A was able to see the shadow of the user in room B. We refer to this scenario as being Distributed with Shadow (DS).

The order in which the different technology scenarios were performed in each session varied according to the experimental design shown in Table 5.1. The duration of each task varied, with the first task being the fastest to be completed. Participants were generally given up to fifteen minutes to perform a task. If they completed the task before the given time, the task was deemed completed. With the shadow technology, the task was interrupted half way (either at 7.5 minutes or when the half of the task had been completed) and the participants changed rooms. This enabled each participant to experience the shadow technology.

| *Session Number* | *Technology Scenario* | | |
|---|---|---|---|
| | *Task 1 (crossword)* | *Task 2 (word search)* | *Task 3 (0s and Xs)* |
| 1, 8 | ND | DNS | DS |
| 2, 7 | ND | DS | DNS |
| 3, 9 | DS | ND | DNS |
| 4, 10 | DS | DNS | ND |
| 5, 11 | DNS | ND | DS |
| 6, 12 | DNS | DS | ND |
| ND=Distributed; DNS=Distributed with No Shadow; DS=Distributed with Shadow | | | |

*Table 5.1 Experimental design for the 12 sessions (by task and technology scenario) for usability study 3.*

Sessions began with an introduction to the study, a brief training session using LIDS, followed by an initial questionnaire that ascertained participants' initial attitudes about the LIDS technology. The main part of the session consisted of the three tasks, each utilising a different technology scenario, and each concluding with a summary questionnaire. When all three tasks and their questionnaires had been completed, a final questionnaire was administered comparing the participants' experiences with the three technologies. This was accompanied by a debriefing.

*Shadow Cameras*

Room B (G1.32) had a camera that was part of the shadow technology. It was situated behind the user and facing the LIDS (about 1.5 m from the LIDS screen). The shadow was seen on the screen in Room A (G1.15).

**Test Environment and Equipment Used**

The study was conducted in two rooms. Room A (G1.15, the group user room and the Department of Computer Science seminar room) was used for the three scenarios, while room B (G1.32, the Human Computer Interaction and Software Development Research Laboratory within the Department of Computer Science) was used for the two distributed scenarios. The general layout of these rooms is given below (see Figure 5.1).

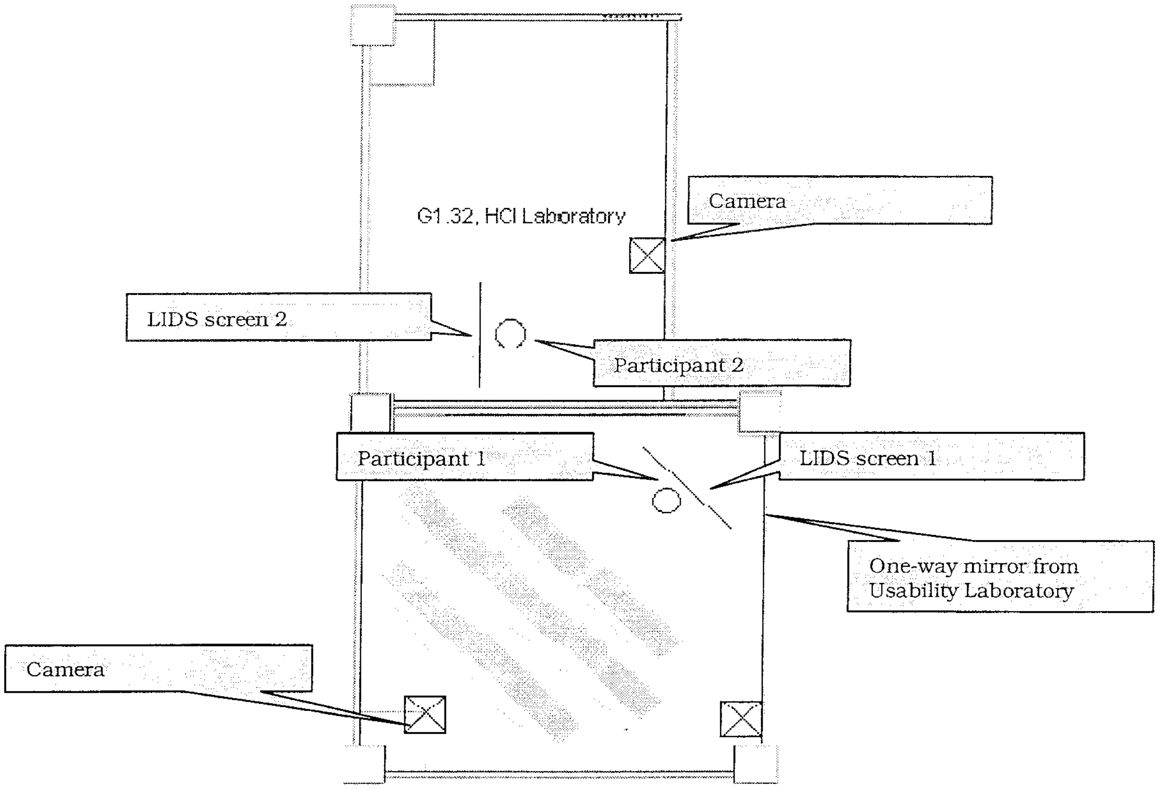



*Figure 5.1 Layout of user rooms (G1.15 (room A) at bottom, G1.32 (room B) at top) for study.*

Three cameras (represented as 'X' in a box in Figure 5.1, above) were placed for observation during the sessions. Room A (G1.15) had two cameras placed for observation: one camera was positioned to view the screen from directly behind the user; the other camera was positioned at an angle in front and to the side of the LIDS giving a view of the user and the screen from behind the right shoulder of the user when facing the screen. Room B (G1.32) had one camera: this was positioned at an angle behind the user to give a view of the user and the LIDS from behind the right shoulder of the user when facing the screen.

Room A also had a scan converter connected to the computer to enable the output from LIDS to be recorded.

A four quadrant mixer was used to combine the four images which were then arranged to show the LIDS screen in the top left hand corner, the camera image directly behind the user in room A in the top right hand corner, the other camera image of the user in room A in the bottom left hand corner and the camera image of the user in room B in the bottom right hand corner. (See Figure 5.2.)

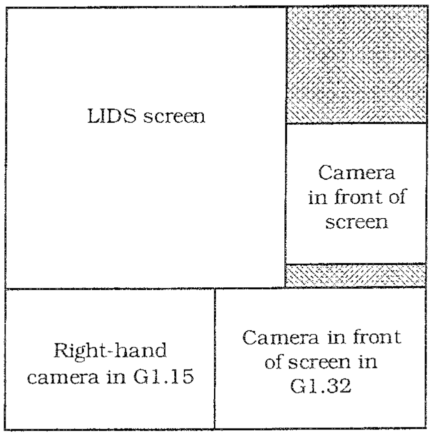



*Figure 5.2 Layout of the four-quadrant mixer.*

**Data Collection**

Data was collected from each session by using five questionnaires (an initial questionnaire, one after each of the tasks, and one summary questionnaire). The initial questionnaire was administered after the training part of the session. It asked the participants about their initial attitudes towards LIDS. The questionnaires administered at the conclusion of each task asked the users about their individual and group experiences with the technology (non-distributed, distributed with no shadow, distributed with shadow). The final summary questionnaire asked the participants to compare their use of the three technologies.

Data was also collected through observation. Observations of each session involved note-taking during the sessions, observation of the video tape recordings of each session, and analysis of the five questionnaires completed by each participant. The participants were also debriefed after each session.

**Participant Mix**

Twenty-four participants were involved in the study. This included 9 females and 14 males. Participants were students of the University of Waikato who recruited by advertising posters displayed on various notice boards around Campus. Two participants were involved in each session. Each session lasted two hours. There were three male pairs, one female pair and eight mixed female-male pairs. These are shown below in Table 5.2 (the gender of each participant is shown in brackets).

Due to a participant failing to arrive at the scheduled time, session 8 was conducted at 2 separate times. In both cases, a worker from the Usability Laboratory played the part of the second person in the study. They played a minimal role in the task and avoided taking the lead in the tasks. No observations were made for this person.

The participant genders, ages, computer experiences are listed below in Table 5.3.

## 5.3 Study Results

The results from the study are given below. Usability problems are discussed first, followed by usability benefits.

**Usability Problems**

The problems that existed with the shadow technology had little to do with the interface and more to do with the users' group interactions and the awareness that the users had of each other.

| *Session Number* | *Participant Number* | |
|---|---|---|
| 1 | P1 (M) | P2 (M) |
| 2 | P3 (F) | P4 (M) |
| 3 | P5 (F) | P6 (M) |
| 4 | P7 (F) | P8 (M) |
| 5 | P9 (F) | P10 (M) |
| 6 | P11 (F) | P12 (M) |
| 7 | P13 (F) | P14 (M) |
| 8 | P15 (M) | P16 (M) |
| 9 | P17 (F) | P18 (M) |
| 10 | P19 (F) | P20 (F) |
| 11 | P21 (F) | P22 (M) |
| 12 | P23 (M) | P24 (M) |

*Table 5.2 Participant pairings for the 12 sessions of the study for usability study 3.*

*Attractiveness and Quality of Shadow*

- **Relevant Usability Principle**: Aesthetic and Minimalist Design
- In terms of the interface or integration with LIDS, the aspects of the shadow technology that participants most frequently disliked related to the quality of the shadow. There were 17 comments, including the large size of the shadow, the low resolution or "grainy" image, the lack of smooth edges, and that the shadow did not provide enough detail about the other participant's gestures.

  *"[The shadow was] large...positioning not exact." (P4)*

  *"Block by recognisable." (P5)*

  *"Shadow actions not always clear." (P6)*

  *"Parts of the other person did not cast a shadow." (P13)*

  *"Shadow slow moving and should have [a] smoother edge." (P18)*

  Seven participants disliked the way in which the shadow technology cast extraneous shadows other than that of the participant. They noted that when other things were cast on the screen it became difficult to read or was confusing.

  Further, when asked to rate the shadow technology along a number of scales (see Figure 5.4), the participants rated the attractiveness and quality of the shadow lower than any other rating.

  The mean over all of the ratings is 1.35. As seen above, the mean for attractiveness and quality is considerably lower at 0.4 and 0.6, respectively.

- **Design Recommendation:** We recommend that the resolution or graininess of the image and lack of smooth edges be improved.

| *Participant* | *Gender* | *Age* | *Computer experience* | *Whiteboard experience* |
|---|---|---|---|---|
| 1 | M | 36 | 15 years; greater than 8 hours per day | Less than 1 year; less than 1 hour per day |
| 2 | M | 25 | 10 years; greater than 8 hours per day | Less than 1 year; 1-3 hour per day |
| 3 | F | 31 | 13 years; 1-3 hours per day | No experience |
| 4 | M | 23 | 13 years; greater than 8 hours per day | Less than 1 year; less than 1 hour per day |
| 5 | F | 21 | 11 years; 1-3 hours per day | Less than 1 year; less than 1 hour per day |
| 6 | M | 27 | 17 years; 1-3 hours per day | No experience |
| 7 | F | 51 | 28 years; less than 1 hour per day | 1-5 years; less than 1 hour per day |
| 8 | M | 21 | 14 years; 1-3 hours per day | 1-5 years; less than 1 hour per day |
| 9 | F | 19 | 9 years; 1-3 hours per day | 1-5 years; less than 1 hour per day |
| 10 | M | 31 | 14 years; greater than 8 hours per day | 6-10 years; less than 1 hour per day |
| 11 | F | 19 | 12 years; less than 1 hour per day | 1-5 years; less than 1 hour per day |
| 12 | M | 22 | 16 years; greater than 8 hours per day | 1-5 years; less than 1 hour per day |
| 13 | F | 23 | 14 years; greater than 8 hours per day | 1-5 years; less than 1 hour per day |
| 14 | M | 34 | 19 years; less than 1 hour per day | Greater than 10 years; less than 1 hour per day |
| 15 | M | 25 | 14 years; greater than 8 hours per day | 1-5 years; 1-3 hours per day |
| 16 | M | 31 | 21 years; 4-8 hours per day | Greater than 10 years; less than 1 hour per day |
| 17 | F | 33 | 14 years; greater than 8 hours per day | 1-5 years; less than 1 hour per day |
| 18 | M | 19 | 9 years; greater than 8 hours per day | 6-10 years; less than 1 hour per day |
| 19 | F | 19 | 7 years; 4-8 hours per day | Less than 1 year; less than 1 hour per day |
| 20 | F | 22 | 14 years; less than 1 hour per day | 1-5 years; less than 1 hour per day |
| 21 | F | 23 | 17 years; 1-3 hours per day | 1-5 years; less than 1 hour per day |
| 22 | M | 20 | 10 years; 1-3 hours per day | 6-10 years; less than 1 hour per day |
| 23 | M | 22 | 12 years; greater than 8 hours per day | 1-5 years; less than 1 hour per day |
| 24 | M | 45 | 8 years; 1-3 hours per day | 6-10 years; less than 1 hour per day |

*Table 5.3 Participant mix for usability study 3.*

*Technical Issues*

- **Relevant Usability Principle**: Error Prevention
- Six participants identified technical problems with the shadow technology. Three noted that it seemed to slow things down and two noted that it seemed to make hearing more difficult. The sixth participants disliked that under the present arrangement only one participant could have the shadow.

*Use of Shadow*

- **Relevant Usability Principle**: Simple and Natural Dialogue
- Four participants said they did not find the shadow helpful or that they could do without it. One of these participants said he did not understand the purpose of the shadow. Five participants found the shadow was (or could be) distracting.

> *"Shadow...distracting." (P4, P10, P12, P19)*
> *"Shadow can be annoying." (P24)*

*Group Collaboration*

- **Relevant Usability Principle**: Error Prevention
- In terms of group collaboration, we asked the participants about how well they thought they had worked in a group together and how aware they were of each other and each other's activities. Surprisingly, the participants ranked how well their group interacted lower when using a shadow than when a shadow was not used.

| | Mean | Individual 95% CIs For Mean Based on Pooled StDev |
|---|---|---|
| | | ---+---------+---------+---------+--- |
| Complex - simple to use | 2.2 | (-----*------) |
| Complex - simple | 1.7 | (-----*------) |
| Unfriendly - friendly | 1.6 | (-----*------) |
| Low tech - high tech | 1.4 | (-----*------) |
| Dislike - like | 1.4 | (-----*------) |
| Unreliable - reliable | 1.4 | (------*-----) |
| Low quality - high quality | 0.6 | (-----*------) |
| Unattractive - attractive | 0.4 | (------*-----) |
| ---+---------+---------+---------+--- | | |
| 0.0 1.0 2.0 3.0 | | |

*Table 5.4 Mean values of participants' perceptions of the shadow technology.*

The participants gave a similar response in the summary questionnaire: they found collaboration hardest when using the shadow. However, the participant comments provide little support for this rating. The most relevant are those that indicate that the participants focused on the shadow/technology more than their task.

> *"Focused on shadow." (P3)*
> *"Increased focus on technology with shadow." (P8)*

Further, the participants indicated that they were only a little more confident that the other user was aware of what they were doing when using a shadow in comparison to not using a shadow.

> *"Shadow obscured a little." (P6)*
> *"Parts of other person did not cast a shadow." (P13)*
> *"Cannot see partner's actions if writing in front of themselves." (P18)*

Perhaps the most telling factor is the small amount of time that each participant spent experiencing the shadow. If they had spent longer with shadow support, they may have become used to the technology and shifted their focus from the shadow onto their tasks and group interactions.

- **Design Recommendation:** We suggest that improvements be made to the attractiveness and quality of the shadow. We further suggest that the shadow work both ways (not just the one as it currently does), and at that stage additional usability studies be carried out on the technology.

*Note: Type of Tasks*

Some participants indicated that the tasks selected for the study were not entirely conducive to collaboration. This was some thing that we noted throughout the study with many of the participants and especially the male participants. Rather than collaborate over the best way of solving and then completing the puzzles, the participants treated the tasks as a competition. At this point, the group interaction and communication broke down, and the participants focused predominantly on the shadow to provide awareness, rather than on verbal communication as well as the shadow. When this occurred, the participants tended to collide with their on-screen movements, placing the pen in the same position or tackling the same part of the puzzle.

In light of this, we recommend that when additional usability studies be performed that tasks be chosen that better encourage collaboration. One example might be for the participants to create a story on LIDS together; another might be to design a web page together.

**Usability Benefits**

Similar to the usability problems that existed with the shadow technology, the benefits had little to do with the interface but more to do with the users' awareness of each other.

*Positive Ratings*

We asked the participants to rate the shadow technology along a number of scales (see Figure 5.3 above). They indicated that they found the technology simple to use and understand, friendly, likeable and reliable. (The participants rated these above the overall mean of 1.35.)

> *"Easy to pick up." (P8)*
> *"Very easy to use, enjoyable, very useful for off-location meetings." (P11)*
> *"Easy, simple, quick (to learn)." (P15)*
> *"Easy to learn." (P17)*
> *"Simple to use." (P19)*
> *"Does not require much training." (P19)*

*Group Collaboration*

In terms of group collaboration, we asked the participants to compare their awareness of each other when using a shadow and when not using a shadow in a collaborative environment. They indicated that they were not only aware of the other user, but were aware of what the other user was doing.

> *"Can see shadow of other person and what they are doing clearly." (P2)*
> *"Shadow gave relative position of other person." (P6)*
> *"Increased awareness." (P5)*
> *"My focus was drawn to her because of the shadow." (P15)*
> *"Could see what [other user was] doing or about to do." (P22)*
> *"Could predict other person's moves from their shadow." (P21)*

*Personal Interaction*

Further, the participants found the existence of the shadow provided for a more personal interaction:

> *"Collaboration more personal." (P4)*
> *"More personal." (P20)*
> *"Having the shadow gave a more personal feel to the interaction." (P20)*
> *"Shadow (knowing where they were) made me feel more comfortable." (P22)*

*Utility*

Although a novelty for a few participants:

> *"...like in cyberspace." (P11)*
> *"Cool and novel." (P13)*

some of the participants valued the utility of the shadow when used within a distributed environment:

> *"Shadow makes it a valuable tool when working on one task in different locations." (P19)*
> *"Shadow technology added that extra dimension." (P22)*

## 5.4 Results in General

Although we have been unable to provide rigorous statistical analysis of the results to answer the two hypotheses formed out the outset of the study, we have been able to provide general findings in relation to them.

The first hypothesis was that the participants would collide less when using LIDS with the shadow. This was correct, but only when the participants continued to discuss what they were doing together. The verbal communication seemed to break down between those groups where at least one of the participants treated the tasks as a competition. Once the verbal communication broke down, it is likely that the participants felt that their interaction was poor.

In comparison, when a shadow was not used in a distributed environment, the participants had no other way to interact other than verbally. Although, their communication may not have been good, they at least discussed their activities in more detail. Some of the participants recognised this as well:

> *"Used audio as well as shadow." (P8)*
> *"Shadow complemented voice." (P20)*

*"Shadow was enjoyable but voice comments more valuable in distributed setup." (P15)*

We suggest that this is an important feature for any collaborative product: verbal interaction can be more valuable than visual communication; thus, it is important that verbal communication be well supported.

The second hypothesis was that the participants would be more comfortable while using LIDS with the shadow. This was also correct, but the participants indicated that they were only comfortable with the shadow when it was used to indicate what the other user was doing. They were not comfortable that the other user knew what they were doing. This shows a distinct lack of trust in the shadow and its ability to enable the users to see all the relative actions of the participants.

# 6. The Presentation Review Tool (A Heuristic Evaluation)

The main purpose of the heuristic evaluation of the presentation review tool was to highlight areas of the tool where improvements could be made to enhance the enjoyment of its use.

## 6.1 Summary

**Summary:** *Previously, we learnt (see the first usability study, Technology in Use for Teachers and Students) that users of the presentation review tool rate its utility value highly. However, we also found that the tool contained a number of technical problems, especially related to slow download times, poor audio quality and unclear video content. These technical problems meant that the participants in the study focused on the technical aspects of the application rather than the material that they wished to review.*

*Further, we also discovered that the participants were a little confused due to the unclear association between annotations and the prepared materials. We also learnt that the participants found the lack of a presenter's image to be impersonal and detracted from any association they may have felt with the presenter.*

*Our heuristic evaluation of the presentation review tool highlighted several other usability problems that will need to be solved to enable the users to gain further satisfaction from using the tool. We suggest that the tool lacks a number of features, particularly previous slide and next slide buttons. Further, a number of existing features need to be improved, such as the audio bar and table of contents pages.*

## 6.2 Evaluation Process

To evaluate the presentation review tool, we reviewed the first LIDS lecture given to the students from the course 0657.209S who participated in the Technology In Use for Teachers and Students study (in this section referred to as the In Use study). The presentation is online and available for review at http://www.cs.waikato.ac.nz/~coms0108/209/lecture11/Slide1.html (last seen 25 June 2002).

We worked our way through a number of slides within the presentation, focusing on the organisation, interaction and navigation, rather than the layout and presentation of the slides.

## 6.3 Evaluation Results

The results from the evaluation are given below. We discuss only usability problems in this part of the report. Usability benefits were highlighted in the In Use study (see section 3 of this report).

**Usability Problems**

Before describing the results from the heuristic evaluation, we reiterate the usability problems found with the tool during the In Use study.

*The In Use Study*

During the In Use study, the participants found that the presentation review tool was slow to download, disassociated annotations with the relevant content, and also had poor audio quality and unclear video quality in many cases. Problems with the audio included: no audio in the laboratories in R-block, the audio bars had no sound, words were missing from the commentary, and some audio clips finished part way through a sentence.

These breakdowns forced the participants to focus on the technology rather than the task of learning. As discussed in section 3, we believe that the technical issues are the most critical and should be the initial focus of any ongoing development.

Further, the participants indicated the need for the presenter's image to be incorporated into the review tool. Thus, we recommended that where possible the presenter's image should be recorded throughout the presentation and then incorporated within the review tool.

*The Heuristic Evaluation*

Although we recommend that it is a good idea to include the presenter's image on the slide, it has not been included in any of the examples below.

*Lack of Linear Sequences*

- **Relevant Usability Principle**: Flexibility and Efficiency of Use.
- There are obvious linear sequences within any presentation. These specifically involve moving from one slide to the next, or back to the previous slide. While reviewing the material, the users are not given this opportunity. Instead (as discussed in section 2.4) the users are required to return to the associated table of contents page to select the next or previous slide.
- **Design Recommendation**: Sequential previous and next links should be incorporated onto every slide. It is important that, where applicable, these same links are on every page so that users will learn to expect, and thus use, these for easy and fast navigation. Generic links such as 'next' or 'previous' can be used but this provides little indication of what content these pages contain. Instead, if able to be implemented, we suggest using 'Next: <title of the next slide>' and 'Previous: <title of the previous slide>'.

  Users should also be able to return to the relevant table of contents from any slide. Instead of placing the link at the end of the audio bar and representing it as a blue 'ToC' button, we recommend that it should now be represented as 'Up: Table of Contents <#>' and placed along the new navigation line at the bottom of each slide

  We have provided examples in Figure 6.1.

*Presentation and Use of Audio Bar*

- **Relevant Usability Principle**: Aesthetic and Minimalist Design.
- Each slide contains the visual/textual presentation (including annotations), as well as an audio bar (see Figure 6.2) which is located at the bottom of the screen. The audio bar is used to indicate the saved audio file for that slide. The audio bar represents the audio in blocks. Pauses in the audio are represented by breaks in the bar. Each block represents audio with no pauses. The arrows beneath each block enable the user to recognise each block. The users are able to access a particular piece of audio by selecting each block, although which block to select is not clear This enables the user to review a specific aspect of the slide if they wish to, rather than forcing the user to listen to the entire audio file for each slide.

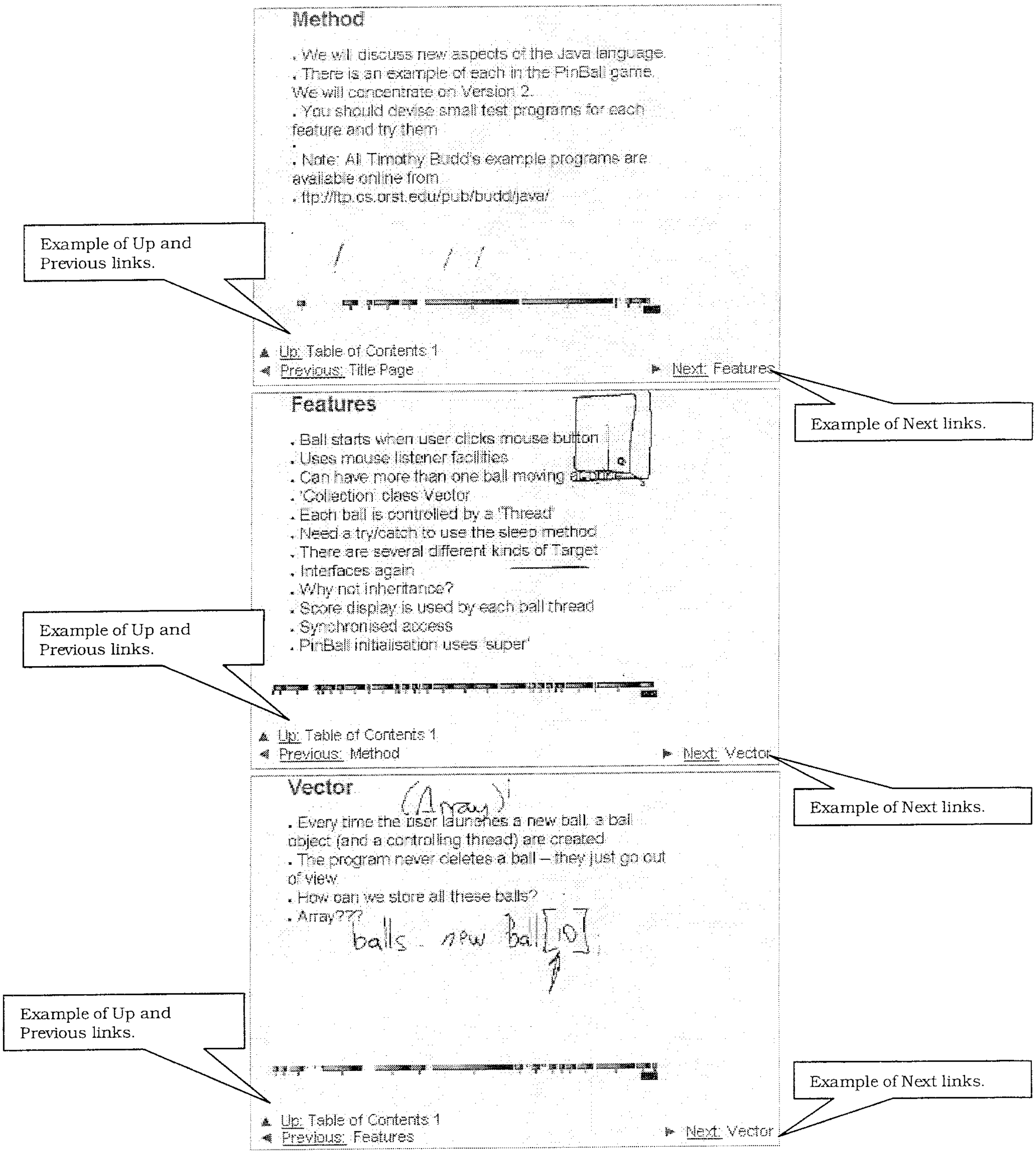



*Figure 6.1 Examples of next and previous links for each slide.*

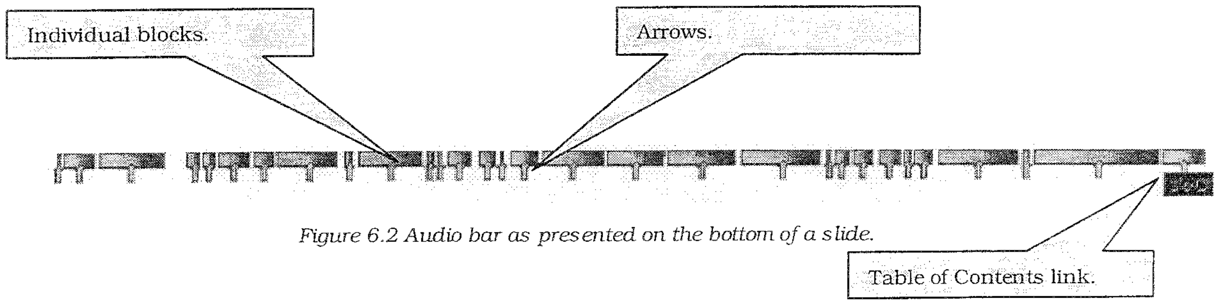



*Figure 6.2 Audio bar as presented on the bottom of a slide.*

One problem is that some audio files can become large and audio bars can become very long and complicated due to an indefinite amount of time spent discussing a slide. The worst case would be when none of the blocks are defined.

Another problem is that users are unable to relate the blocks with any significant occurrence during the presentation of that slide. The arrows are used only to identify individual blocks.

- **Design Recommendation**: We recommend that after certain length of time, say 10 minutes, on one slide that an identical slide be inserted into the presentation and the presenter works on the inserted slide. If this recommendation is adopted, the insertion must seem seamless, as if nothing has taken place. However, this will mean that discussions on one topic might continue over more than one slide, which may mean that locating a specific item can become more difficult.

  We also recommend that to simplify the graphics involved, that the audio bar be replaced with one long continuous bar with arrows removed. (Colours might still be used to indicate when the presenter is actually saying something.) To enable users to better relate the audio with a significant occurrence during the presentation of the slide we suggest that thumbnails of the presentation of the slide be placed at regular intervals along the bar. The thumbnails should represent snapshots of the presentation taken at regular intervals (see Figure 6.3). Instead of selecting the audio bar to play audio, the users might be able to select the thumbnails to indicate that they wish to listen from that point on the slide onwards.

  This will enable users to better associate sections of the audio with progression through the slide and it will look less complicated than the current audio bar.

  The problem with this recommendation is that it assumes the presenter will make annotations so that the user can easily differentiate between phases on the slide, and as seen above in Figure 6.4 it will take up more space on the slide.

*Table of Contents Pages*

- **Relevant Usability Principle**: Flexibility and Efficiency of Use.

- The table of contents slides currently consists of one or more screens with each screen containing a two-by-four matrix of slides. Thus, if more than eight slides exist in the presentation then additional table of contents screens are provided. Arrows, displayed at the bottom of the table of contents screens, enable the user to navigate to the first (◀◀), previous (◀), next (▶) and last ( ▶▶) group of table of contents slides. A numeric list (e.g. 1 2 3 4) that represents each of the table of contents screens is also given. The numbers are underlined to indicate that these are navigable. On selection, the user is able to navigate directly to a particular table of contents screen. Each table of contents screen is also listed with the title "Table of Contents" and a number to represent the table of contents screen that the user is currently viewing. Thus, the second table of contents screen would contain the tile "Table of Contents 2.".

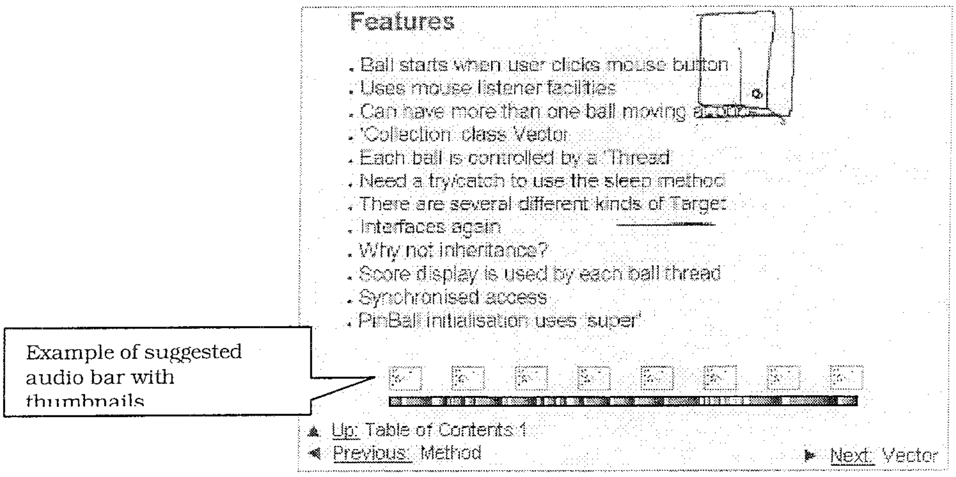



*Figure 6.3 Example of audio bar with thumbnails.*

The issue with the table of contents slides is that the users are not able to determine the full range of topics within the presentation at a glance. Because the table of contents are displayed over multiple slides, users who require a particular slide but are unsure of where in the presentation it was displayed are forced to navigate through each table of content slide until they locate the required slide. The small size of the thumbnails currently used make it difficult to determine the exact contents of a slide other than its title. For this reason we suggest that providing thumbnails in the table of contents does not add anything useful.

- **Design Recommendation**: We recommend that the multiple table of contents slides within the presentation review tool be replaced by a single table of contents slide (see Figure 6.4 for an example).

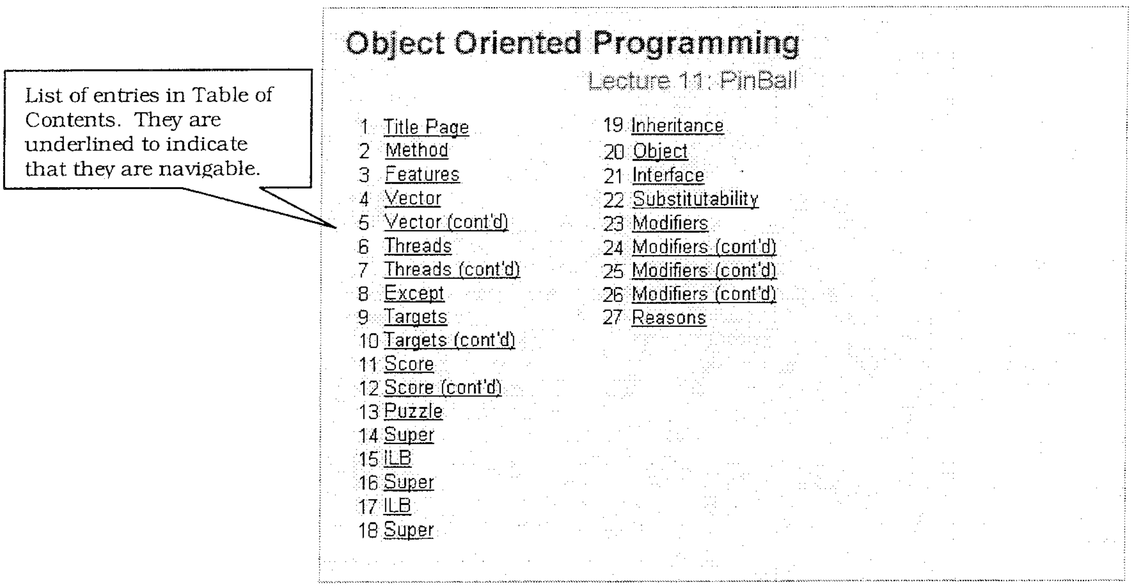



*Figure 6.4 Example of table of contents.*

We recommend that only the titles of each slide be displayed, instead of a thumbnail image.

These suggestions have ramifications for the 'Up: Table of Contents <#>' navigation feature suggested earlier. Instead of having multiple table of contents slides, there would now be only one. The 'Up: Table of Contents <#>' could be replaced with 'Up: Table of Contents' or by 'Up: Home', where 'Home' represents the table of contents slide (see Figure 6.5).

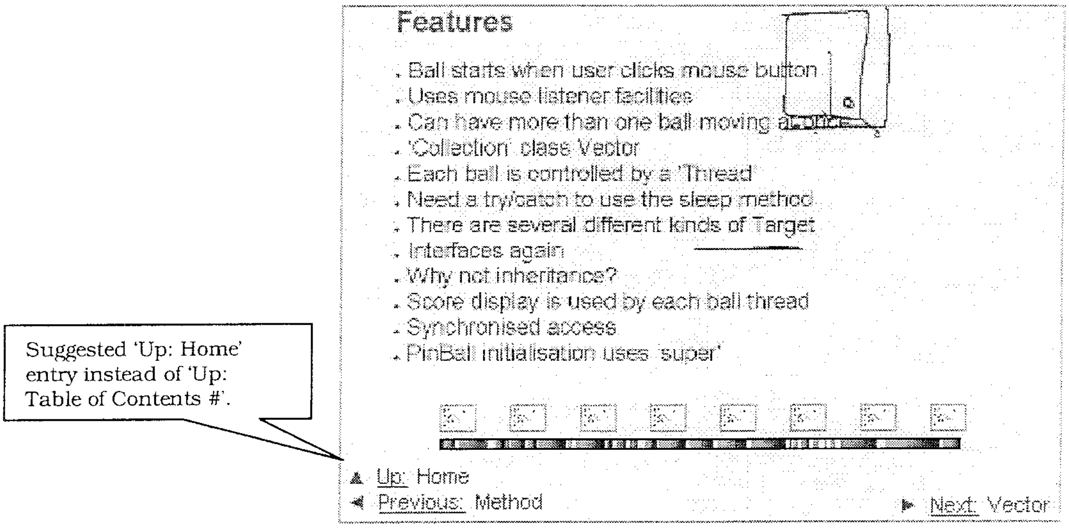



*Figure 6.5 New example of slide with 'Up: Home' navigation link.*

## 6.4 Results in General

As indicated in the In Use study, the participants valued the ability to review the entire presentation after it had taken place, in a way that they could control. The participants of the study could understand the utility value of the LIDS review tool. The participants found that their ability to access missed material while using the review tool meant that they caught up on material or reinforced their learning.

The suggested incorporation of the presenter's image, suggested from the In Use study as well as above, mean that the users should have a better awareness of, and association with the presenter. The users should also be able navigate the slides in a more natural manner by being able to select the previous and next slides and to go to the home slide from any slide in the presentation. The changes suggested to the audio bar also mean that the users can relate the material on the slides with the audio in a more direct way. The suggested changes to the table of contents pages means that the users do not have to navigate through more slides than is necessary to locate the material that they wish to review.

# 7. The Physical Technology: Ergonomic Issues (An Observation)

This section of the report focuses on ergonomic aspects of the LIDS pen and screen. It draws from all three usability studies (discussed earlier in this report) as well as observations made outside of the usability studies.

## 7.1 Summary

***Summary:*** *During our usability studies we observed that the participants generally liked the pen, appreciating that it not only replaced the mouse but that it did so in an easier, more natural way. Similarly, we found that the participants really enjoyed interacting with the large screen. When used in combination with the pen and interactive gestures, we observed the participants acting in a more natural, open and interactive manner.*

*However, a number of ergonomic issues exist. For the screen, these included its inflexible height and physical detachment from the computer keyboard. For the pen, the ergonomic issues included its large and bulky size and shape, which made it difficult to grip and write on the screen with ease.*

**The Large Interactive Display Screen**

The LIDS Research Project has developed a low-cost large display screen that is used with surface digitizing and computer projection. It can be used in a similar way to a whiteboard. For more details see section 2.2 of this report.

**The Mimio™ Pen**

The Mimio™ pen is used in place of the computer mouse for navigation and drawing of on-screen artefacts, such as gestures and on-screen text. The Mimio™ pen is described in more detail in section 2.1 of this report.

**Testing the Physical LIDS Technology**

To learn about usability problems associated with the physical LIDS technology, we incorporated relevant questions into the questionnaires used for each of the usability studies. We observed the participants as they used LIDS in usability studies 2 and 3, the teacher as he used LIDS in usability study 1, and the students as they observed the lectures in usability study 1. We have also observed LIDS in use outside of the usability studies and incorporated these findings in this section.

**Usability Problems (In Brief)**

Several usability problems were experienced with both the Mimio™ pen and the LIDS screen, as well as some other features such as the eraser and the right-mouse button.

*The Mimio™ Pen*

- The **bulky and awkward size and shape** of the pen meant that many of the users found **holding the pen difficult and uncomfortable**, especially with prolonged use.
- The required angle (near-horizontal) of the pen when used to draw on the screen, particularly on those areas of the screen that were lower (e.g. at or below stomach level) and/or higher

(e.g. above head height) than the users' comfort zone (e.g. chest, shoulder or head levels), meant that **applying consistent pressure and maintaining contact was difficult.**

- The difficulties experienced when drawing on the screen meant that the **users focused on the technicalities of writing rather than on their tasks.**
- The design of the pen means that **accessing, extracting and inserting batteries is tedious.**

*The LIDS Screen*

- The screen was seen to be **unattractive.**
- **Poor screen readability** due to: **lighting** (a lack of contrast between the projected image and room lighting), **reflection** (from room lighting onto the screen), **glare** (from the projector behind the screen), and **distortion** (of colours when close up).
- **Inflexible screen height** means that **shorter users can not reach the top comfortably** and **taller users have to stoop** a little in order to access the bottom of the screen.
- **Difficult access to the keyboard**, when used to enter text, causes frustration for the users.
- A **lack of easy portability** restricts the use of the screen to limited environments.
- **Unsafe physical features** of the screen, e.g. supporting brackets that stick out close to where the users stand, means that users need to be continuously aware of what they are doing and where they stand in relation to the screen.

*Other Features*

- **Difficult access to the right mouse button,** which was located on the Mimio™ digitiser means that users infrequently use it or find it annoying to use.
- **Separate input devices** (i.e. Mimio™ pen and Mimio™ mouse) suggests a redundancy in use.

Our findings from the usability studies and our own observations indicate that the LIDS physical technology (the pen and the screen) needs to be improved in a number of areas. Doing so will mean that the users will become less conscious of the physical technology, focusing more on their tasks instead.

**Usability Benefits (In Brief)**

Although the participants in the studies experienced difficulties while using the physical technology, they also found parts of it very useful and usable.

*The Mimio™ Pen*

- The pen was seen as **simple and friendly.**
- The pen was found to be **easy to use and write with.**

*The LIDS Screen*

- The screen was seen as **simple.**
- The screen was found to be **easy and enjoyable to use.**

- The **large screen size** was generally liked as it **allowed more than one person to work around the screen at the same time,** and **allowed an audience to easily see what the presenter was doing.**

Most users enjoyed working with the LIDS screen and using the Mimio™ pen instead of a computer mouse. They saw both the pen and screen as simple technologies that are comparable to the whiteboard and that attract both experienced and inexperienced computer users.

## 7.2 Usability Studies

The usability studies are described in sections 3, 4 and 5 of this report.

**Objectives**

Each study consisted of two objectives. The first objective was related to the specific technology being studied. The second objective focused on the ergonomic and interactive features of the physical LIDS technology. The ergonomic features included the Mimio™ pen and LIDS screen, the effect on the users' posture and the overall sustainability of using LIDS while performing various tasks.

**Problem Statements**

Each study consisted of a number of problem statements. These could generally be grouped into those that targeted the specific technology being studied and those that targeted the ergonomic and interactive features of the physical LIDS technology. The statements that referred to the latter included:

1. Do users find it ergonomically comfortable to work on a surface that is vertical (LIDS)? Is it preferential to using the desktop (and mouse) for the same tasks?
2. Are the LIDS pens 'comfortable' to use? Are they initially 'comfortable' in the users hands? Do they remain so after a longer period of time has elapsed?
3. Are the LIDS pens 'easy' to use? How much effort do the users put into determining how the pens work? Do they begin using the pens straight away without any queries or practice or do they require some instruction? Are they able to work fairly 'naturally'?

**Data Collection**

Data relating to the physical LIDS technology was collected using questionnaires and through observation. The questionnaires were used in each of the usability studies described in earlier sections of the report. Observation took place during the studies, and through interaction with the technology outside of the studies (i.e. during LIDS research project meetings and through our own experiences).

## 7.3 Results

The results from the questionnaires used in the studies, and our observations both in and beyond the studies are given below. Usability problems are discussed first, followed by usability benefits.

**Usability Problems**

Both the Mimio™ pen and the LIDS screen had usability problems. Our observations suggest that even though the users became accustomed to using the pen and screen, this does not mean that the problems should not be addressed.

*The Mimio™ Pen*

A number of problems were identified in the summary. These include:

- The bulky and awkward size and shape of the pen meant that many of the users found holding the pen difficult and uncomfortable, especially with prolonged use.
- The required angle (near-horizontal) of the pen when used to draw on the screen, particularly on those areas of the screen that were lower (e.g. at or below stomach level) and/or higher (e.g. above head height) than the users' comfort zone (e.g. chest, shoulder or head levels), meant that applying consistent pressure and maintaining contact was difficult.
- The difficulties experienced when drawing on the screen meant that the users focused on the technicalities of writing rather than on their tasks.
- The design of the pen means that accessing, extracting and inserting batteries is tedious.

We address only two problems (the bulky nature of the pen and the difficult access to the battery) below. The usability problems listed under Other features (see above) are also described in more detail here, as they influence the design recommendations for the pen.

*The Mimio™ Pen: Bulky Size and Shape*

- **Relevant Usability Principle**: Aesthetic and Minimalist Design.
- The Mimio™ pen (see Figures 7.1 and 7.2) is a capsule-type device that fits a 'plastic pen' similar to that used for whiteboards.

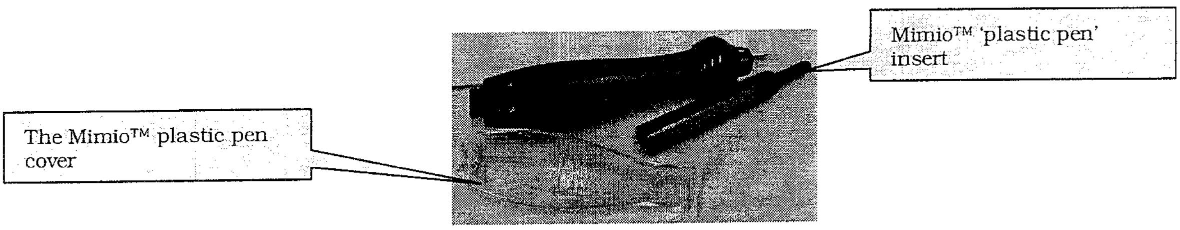



*Figure 7.1 The separate Mimio™ pen parts.*

The 'plastic pen' has a hard plastic nib. After some use, the LIDS Research Project found the hard nib uncomfortable to use. They have now replaced the 'plastic pen' with a used whiteboard marker containing no ink. This provides a softer tip that grips the surface of the screen more easily than before.

The part of the Mimio™ pen that is held by the user curves outwards to the end of the pen.

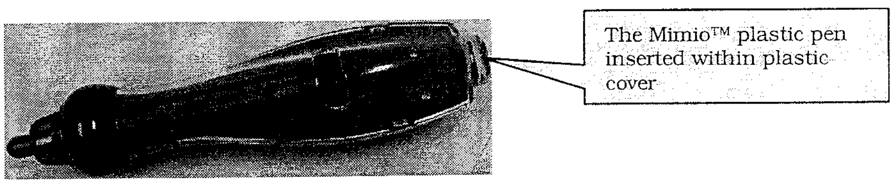



*Figure 7.2 The Mimio™ pen as one piece.*

The participants in two of the studies (usability studies 2 and 3) found the pen to be bulky and an awkward size and shape.

> *"Pen too big." (S3,P17)*
> *"Too big to hold." (S2,P3)*

*"Pen to big to handle." (S3,P2)*
*"Too large to hold easily." (S2,P6)*
*"Pen big and heavy." (S3,P7)*
*"Pen to bulky." (S2,P16)*
*"Bulky." (S2,P1)*
*"Pen is cumbersome." (S3,P13)*
*"Difficult to get a decent grip and draw how I wanted to." (S3,P11)*

- **Design Recommendation:** We recommend that the shape of the pen be altered to better represent a whiteboard pen, which is narrower along all parts of the pen (see Figure 7.3). As the participants of the studies and most of the other users we have observed have used the LIDS pen with pre-used whiteboard pens with ink that has run out in place of the plastic pen that comes with the Mimio™ pen, we suggest that the nib be similar to that of a whiteboard pen.

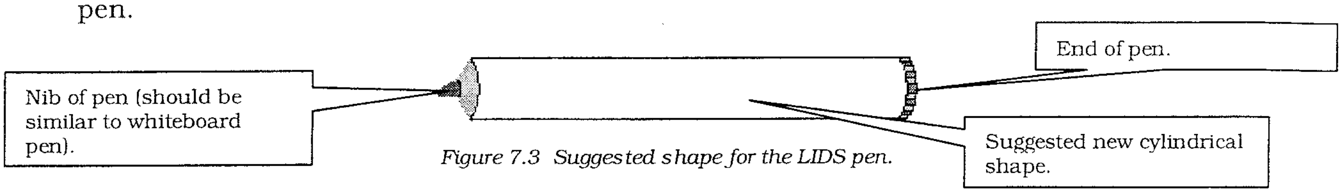



*Figure 7.3 Suggested shape for the LIDS pen.*

*The Mimio™ Pen: Accessing the Battery*

- **Relevant Usability Principle**: Simple and Natural Dialogue
- The current Mimio™ pen has electrical componentry and is run by battery. The battery is accessed, inserted and extracted by the user, who has to remove the plastic covers, of which one is attached by screws.
- **Design Recommendation:** To make changing the battery easier for the user, we recommend that the position of the battery be moved to the end of the re-designed pen (see Figure 7.4).

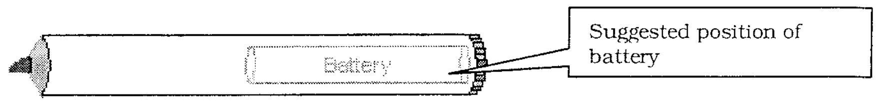



*Figure 7. 4 Suggested position of battery in redesigned LIDS pen.*

Access can be given by enabling the user to unscrew the pen three-quarters of the way up the pen (near the end), allowing the users to easily access, extract and insert batteries (see Figure 7.5). The position of this access should not hinder use of the pen.

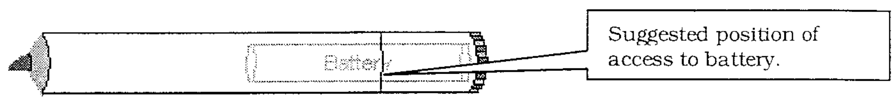



*Figure 7.5 Access to battery in redesigned LIDS pen.*

*The Mimio™ Pen: The Mimio™ Eraser*

- **Relevant Usability Principle**: User Control and Freedom; Flexibility and Efficiency of Use
- The current Mimio™ eraser is separate from the Mimio™ pen. The Mimio™ eraser (see Figures 7.6 and 7.7) is round (to fit in the palm of the user's hand) and flattish. It sits in it's own pocket (see Figure 7.6), that can be attached to the side or bottom of the screen.

The eraser has two eraser heads: one round and large that sits at the bottom of the eraser (see (i) in Figure 7.7); the other is smaller and is attached to the side of the eraser (see (ii) in Figure 7.7).

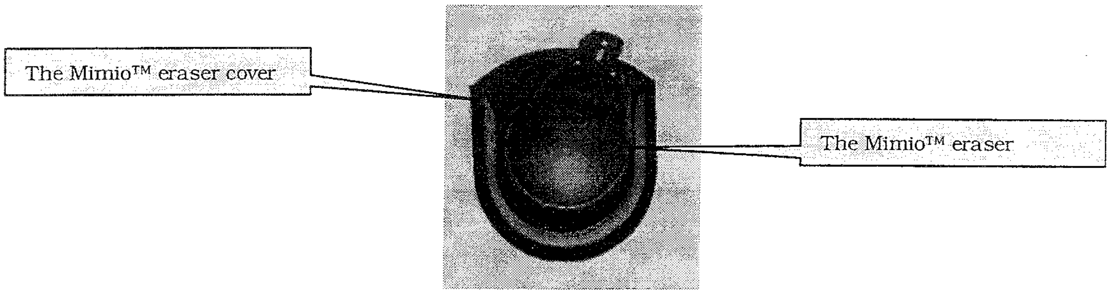



*Figure 7.6 The Mimio™ eraser inside it's own pocket. The pocket can be attached to the side or bottom of the screen.*

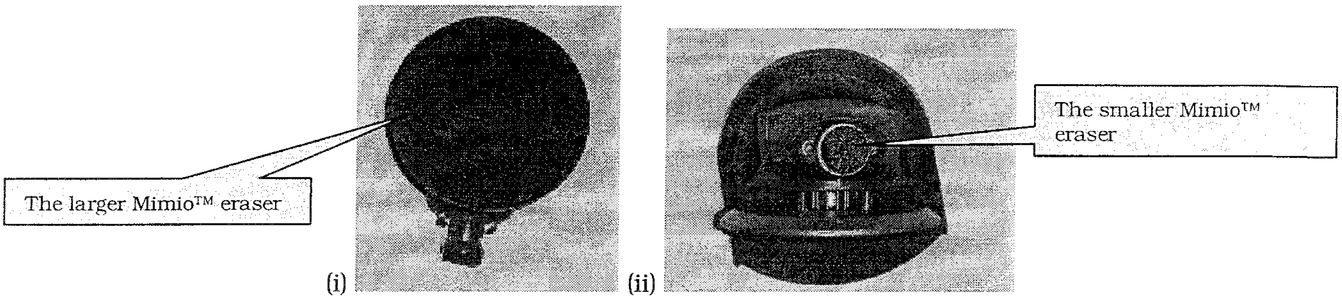



*Figure 7.7 The erasing points to the Mimio™ eraser. In (ii) the eraser is sitting side ways on top of the eraser pocket.*

As part of the interactive gesture set, a delete gesture (a zigzagging motion) has been created. As described in the results for the second usability study (see section 4 of this report), the delete gesture proved problematic for most participants and we suggested that the Mimio™ eraser be re-adopted for use for erasing unwanted material.

- **Design Recommendation:** On current whiteboards (as with the Mimio™ technology), pens and erasers are separate. Thus users have to ensure that they have both tools on hand at all times. We believe that this can be simplified, purely by combining the tools in some way. One way to do this could be by attaching an eraser to the end of the pen, akin to a pencil with an eraser on the end (see Figure 7.8).

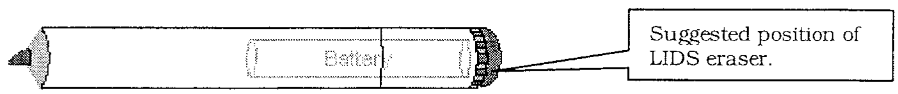



*Figure 7.8 New LIDS pen with eraser at end.*

However, one problem with this suggestion is that the users will be restricted to using an eraser of only one size, rather than the two sizes (larger and smaller) currently available (see Figure 7.7, above). Perhaps this issue can be solved by enabling the users to place the eraser end of the pen on the screen. If they require a larger eraser than that on the end of the pen, then they need to keep pressure in the same position on the screen. As they do so, the area around the eraser point is erased and the erased area grows larger with the application of the pen in the one position.

This is not an intuitive action and the users would need training in its use.

*The Mimio™ Pen: The Right Mouse Button*

- **Relevant Usability Principle**: User Control and Freedom; Flexibility and Efficiency of Use

- The Mimio™ pen is used as a replacemnt to the computer mouse when the left mouse button (on a Windows™ machine) has been selected. Users are still required to use software features that are available or operated with the right mouse button. Mimio™, in recognising this requirement, have placed a right mouse button on the Mimio™ digitiser—the digitiser sits on one side of the LIDS screen.

  The issue is that access to the right mouse button can be problematic—users have to remember which is the correct button to select (there are five buttons in total) and they have to stop what they are doing and walk to the digitiser to select it.

- **Design Recommendation:** We recommend that an easy toggle feature be incorporated with the pen. The toggle feature must be easy to access but must not inhibit the use of the pen by being in the wrong place i.e where the users will typically hold and write with the pen. We suggest a little button, reachable by one of the user's fingers that sits on top of the pen, may be the best position. The suggested placement is given below in Figure 7.9.

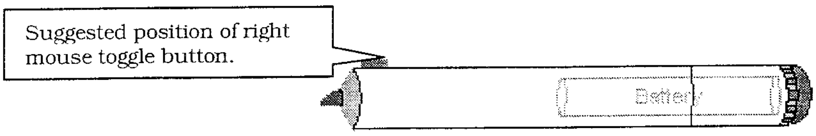



*Figure 7.9 Suggested placement of toggle button on redesigned LIDS pen.*

*The LIDS Screen*

A number of problems were identified in the summary. These include:

- The screen was seen to be unattractive.
- Poor screen readability due to: lighting (a lack of contrast between the projected image and room lighting), reflection (from room lighting onto the screen), glare (from the projector behind the screen), and distortion (of colours when close up).
- Inflexible screen height means that shorter users can not reach the top comfortably and taller users have to stoop a little in order to access the bottom of the screen.
- Difficult access to the keyboard, when used to enter text, causes frustration for the users.
- A lack of easy portability restricts the use of the screen to limited environments.
- Unsafe physical features of the screen, e.g. supporting brackets that stick out close to where the users stand, means that users need to be continuously aware of what they are doing and where they stand in relation to the screen.

We address only one problem (difficult access to the keyboard) below. The remaining problems have solutions and implications beyond our scope.

*The LIDS Screen: Access to the Keyboard*

- **Relevant Usability Principle**: User Control and Freedom; Flexibility and Efficiency of Use.

- During a presentation, users still need to input text in real time. With the current LIDS setup this can be done by using the computer keyboard or by drawing the text on the screen with the Mimio™ pen. User-drawn on-screen text is often large and can be unreadable. Ideally, users should be able to have their characters recognised by the software and represented as computer-typed letters. However, this facility does not yet exist. Further, providing users with the flexibility of using character recognition or the keyboard would have its advantages. Currently, the computer keyboard tends to be attached and more physically closer to the computer rather than the screen. This means that users must detach themselves from the screen in order to use the keyboard.

- **Design Recommendation:** We recommend that the computer keyboard be better physically located to the screen. We suggest that it might be placed on a retractable and rotating keyboard holder (i.e. one that is attached to the bottom of the LIDS), so that users can move it to a more comfortable and useful position (see Figure 7.10).

**Usability Benefits**

A number of usability benefits have been identified. These are mostly refer to the simplicity of the pen and screen. Both the concept and use of the physical technology are easy and this is what attracts the users.

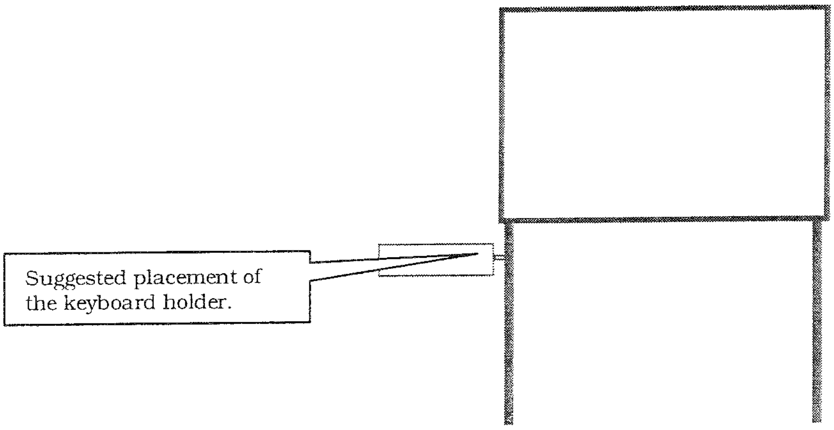



*Figure 7. 10 Suggested placement of the keyboard holder in relation to the LIDS screen.*

*The Mimio™ Pen: Easy to Use and Write With*

Most participants of the studies found the Mimio™ pen easy to learn to use and write with.

> *"A lot like using a mouse." (S2,P4)*
> *"Pen...easy to use." (S3,P3; S2 P1; S2,P4)*
> *"Like a normal pen, but doesn't run out or smudge." (S3,P5)*
> *"...easy to write with." (S3,P8; S2,P8; S2,P15)*
> *"Like using pen and paper." (S3,P17)*
> *"Pen easy to use on screen." (S2,P6)*

*The Mimio™ Pen: Simple and Friendly*

We asked the participants of the second study, Interactive Gesture Recognition Tools, to rate the pen along a number of scales. The scales were made up of extremes: complex – simple, complex to use – easy to use, unfriendly – friendly, and so on. The participants rated the simplicity and friendliness of the technology highly.

*The LIDS Screen: Simple and Easy to Use*

We asked the participants of the second and third studies, Interactive Gesture Recognition Tools and the Shadow Technology (respectively), to rate the pen along a number of scales. The scales were similar to those used for the Mimio™ pen, and were made up of extremes: complex – simple, complex to use – easy to use and so on. The participants rated the simplicity and ease of use of the technology highly.

*The LIDS Screen: Size of Screen*

The participants of the second and third studies, Interactive Gesture Recognition Tools and the Shadow Technology (respectively), were asked to list features of the screen that they liked. Twenty-two participants indicated that they liked the size of the screen. Twelve liked the way in which the large screen facilitated visual clarity and ease of reading. Five participants like that it provided a large surface on which to work or that could accommodate more than one person working around the LIDS screen at one time.

> *"Large screen—easy for audience to see." (S3,P16)*
>
> *"Large and easy to read." (S3,P20)*
>
> *"Size of screen perfect for creating a presentation; sufficient room for text and images." (S2,P5)*
>
> *"Nice and large (more than one person can work at it)." (S2,P3)*

## 7.4 Results in General

A number of usability problems have been highlighted in this section of the report. Some issues have been beyond our scope, so we have not discussed them in further detail. We have tried to address some issues, particularly those associated with the pen.

Throughout the studies and from our own observations we have found that the users have been comfortable working on the LIDS screen. They like the large screen size as it enables them to share their on-screen artefacts a lot more easily. The use of the LIDS screen and the Mimio™ pen seemed almost preferential to using the traditional computer screen and mouse.

However, the very size of the screen can be restrictive. The height may disadvantage smaller users, but lowering it will likely cause taller users problems. The current width means that accessing functions, such as the right mouse button, can be tedious. Making these functions more accessible, i.e. by merging them with the pen, may solve this type of problem.

The Mimio™ pen, although reasonably comfortable, may prove better if made smaller and more light-weight—especially for longer term use.

Finally, we found that the best feature of the LIDS screen and the Mimio™ pen was their simplicity, which the users find attractive.

# 8. Summary

This report represents the Usability Laboratory's analysis of the Large Interactive Display Screen (LIDS) technologies developed by the LIDS research group.

The Usability Laboratory has conducted three exploratory-type studies of the LIDS technology over January and February 2002. The studies each focused on individual elements of the LIDS technology, while at the same time contributing to the general understanding and knowledge of the technology.

The first study, Technology in Use for Teachers and Students, focused on the support that the LIDS technology provided for both in-class presentation of learning information and the review of the learning material outside the class environment. The second study, Interactive Gesture Recognition, focused on the use of sometimes-used gestures (on-screen strokes) that provided the ability to navigate a LIDS presentation. The third study, Shadow Technology, focused on the use of a shadow to facilitate awareness between LIDS users in distributed locations.

The Usability Laboratory also conducted a heuristic evaluation of the Presentation Review Tool associated with the first usability study, Technology in Use for Teachers and Students, so as to highlight areas of the tool that could be improved upon. From the three studies and also previous observations the Usability Laboratory has also observed some interesting ergonomic issues regarding the physical LIDS technology.

This report has presented the findings of each of the studies, the separate heuristic evaluation of the presentation review tool, and observations of the physical technology. The findings have been separated into usability problems and usability benefits. For every benefit we have highlighted, we have provided a general description and discussed the participants' thoughts. For every problem that we have described, we have indicated the relevant usability principle (or principles) broken, and tried to recommend at least one design solution to the problem, although a range of alternate design solutions have been generally sought. These were to be used as the basis for further discussion rather than being the ultimate and final resolution. As such, and where applicable, we discussed the usability advantages and disadvantages of each recommendation given. Where possible, we have provided graphic ex amples.

## 8.1 Usability Problems

Our usability studies highlighted elements of the technology that forced users to focus on the technology rather than their tasks or the collaboration taking place.

In the first usability study, Technology in Use for Teachers and Students, these usability problems included poor visibility and readability of the LIDS screen and the technical instability of the LIDS software for presentation and review. The latter should be the first priorities to solve.

In the second usability study, Interactive Gesture Recognition Tools, the usability problems included the delete gesture (in general), other gestures being drawn incorrectly, a lack of an easy undo mechanism, unclear modes, collisions with unintentional gestures, hidden on-screen software options, difficult readability of on-screen text, and a restricted set of interactive gestures.

In the third usability study, The Shadow Technology, the usability problems included a lack of confidence, on the part of the users, of whether the other user was aware of what they were doing. Further, the users indicated that their interaction and communication with the other user was not as good as working in the same room together or even working in two separate locations that had no shadow.

In the heuristic evaluation of the presentation review tool, we suggested that the tool lacked a number of features, in particular previous slide and next slide buttons. Further, a number of existing features needed to be improved, including the audio bar and the table of contents pages.

From our observation of ergonomic issues related to the physical LIDS technology, we suggested that the inflexible height of the LIDS screen and physical detachment of the computer keyboard from screen caused problems for the users. For the pen, we suggested that the participants found its large and bulky size and shape difficult to grasp and write on the screen with ease.

## 8.2 Usability Benefits

Our usability studies also highlighted some major benefits that can be derived from the technology for a group of users collaborating over the same task

In the first usability study, Technology in Use for Teachers and Students, the participants viewed the technology positively. They indicated that it was as good as, if not better, than other more traditional or better-known presentation media (i.e. blackboard, whiteboard, OHP or Powerpoint™.). The participants also liked being able to review material online after the lecture as it allowed them to reinforce or improve upon what they had learned in class.

In the second usability study, Interactive Gesture Recognition Tools, we established that most participants found that all of the gesture recognition tools, except the delete gesture, easy to use, simple and reliable. All the participants indicated that they enjoyed using the LIDS technology and the gesture recognition tools to perform their presentations.

In the third usability study, The Shadow Technology, we established that most of the participants were generally positive about the use of the shadow to support awareness of other users during collaborative activities.

From our observation of ergonomic issues related to the physical LIDS technology, we suggested that the users generally liked the pen, appreciating that it not only replaced the mouse but that it did so in an easier, more natural way. Similarly, we found that they really enjoyed interacting with the large screen. When used in combination with the pen and interactive gestures, we observed the participants acting in a more natural, open and interactive manner.

## 8.3 Implications for LIDS

From our studies we learnt that LIDS provides the development and delivery of material in a flexible and transparent manner. Existing material can be shared, and the WYSIWYD (What You See I What You Do) environment enables important information to be easily highlighted and new material added in a way that strongly supports the spontaneity and natural evolution of a collaborative setting.

The stand out feature was its simplicity—an attraction for both experienced and inexperienced computer users. We found many of its implemented features were easy to use.

We suggest that the LIDS technology has potential for a wide range of collaborative events, such as design sessions, learning sessions for children and the disabled, information/data sharing and discussions, and meetings and presentations. Being computer driven means that it can be expanded and integrated with other computer technologies to meet the needs of specific applications, which may include online learning, data collection and dissemination with the support of such technologies as small screen devices for areas such as health and law enforcement.

## 8.4 Summary of Design Recommendations

### The Presentation Tool

*Design Recommendation: Replace the Pencil Image with a Simple Cross*

We recommend that the pencil image be replace with a simple cross (see Figure 3.4) with the centre of the cross corresponding to the tip of the pen when placed on the screen. This should minimise the graphics used and cause existing text that originally sat behind the image to be viewable.

### The Presentation Review Tool

*Design Recommendation: Incorporate the Video of the Presenter within the Review of the Presentation*

We recommend that where able the presenter's image should be recorded throughout the presentation and then incorporated within the review tool. The image does not need to be large (see Figure 3.5), and the position of the image within the slides could be determined by the presenter before putting the material online.

*Design Recommendation: Incorporate Next and Previous Links*

Sequential previous and next links should be incorporated onto every slide. It is important that, where applicable, these same links are on every page so that users will learn to expect, and thus use, these for easy and fast navigation. Generic links such as 'next' or 'previous' can be used but this provides little indication of what content these pages contain. Instead, if able to be implemented, we suggest using 'Next: <title of the next slide>' and 'Previous: <title of the previous slide>'.

Users should also be able to return to the relevant table of contents from any slide. Instead of placing the link at the end of the audio bar and representing it as a blue 'ToC' button, we recommend that it should now be represented as 'Up: Table of Contents <#>' and placed along the new navigation line at the bottom of each slide. We have provided examples in Figure 6.1.

*Design Recommendation: Insertion of Identical Slide After Some Time*

We recommend that after certain length of time, say 10 minutes, on one slide that an identical slide be inserted into the presentation and the presenter works on the inserted slide. If this recommendation is adopted, the insertion must seem seamless, as if nothing has taken place. However, this will mean that discussions on one topic might continue over more than one slide, which may mean that locating a specific item can become more difficult.

*Design Recommendation: Replace Audio Bar With Simplified Version and Incorporate Thumbnails of Slide*

We also recommend that to simplify the graphics involved, that the audio bar be replaced with one long continuous bar with arrows removed. (Colours might still be used to indicate when the presenter is actually saying something.) To enable users to better relate the audio with a significant occurrence during the presentation of the slide we suggest that thumbnails of the presentation of the slide be placed at regular intervals along the bar. The thumbnails should represent snapshots of the presentation taken at regular intervals (see Figure 6.3). Instead of selecting the audio bar to play audio, the users might be able to select the thumbnails to indicate that they wish to listen from that point on the slide onwards.

This will enable users to better associate sections of the audio with progression through the slide and it will look less complicated than the current audio bar.

The problem with this recommendation is that it assumes the presenter will make annotations so that the user can easily differentiate between phases on the slide, and as seen in Figure 6.4 it will take up more space on the slide.

*Design Recommendation: Replace Multiple Table of Contents Slides With One Table of Contents Slide*

We recommend that the multiple table of contents slides within the presentation review tool be replaced by a single table of contents slide (see Figure 6.4 for an example).

*Design Recommendation: List Slides By Their Title*

We recommend that only the titles of each slide be displayed, instead of a thumbnail image.

*Design Recommendation: Alternative Up Solution*

The suggestions (above) have ramifications for the 'Up: Table of Contents <#>' navigation feature suggested earlier. Instead of having multiple table of contents slides, there would now be only one. The 'Up: Table of Contents <#>' could be replaced with 'Up: Table of Contents' or by 'Up: Home', where 'Home' represents the table of contents slide (see Figure 6.5).

**The Interactive Gestures**

*Design Recommendation: Enabling Gestures to be Used Correctly*

A range of recommendations are given.

- Provide a separate training module where each of the gestures is pre-drawn (similar to those that were drawn on the whiteboard for the training part for each session for the second and third usability studies) and the user over-draws the gestures, mimicking the size and shape of each gesture as it is pre-drawn on the slide. This offers users with the ability to train and practice at any time. Further the users have an on-line reference from which they can determine the right size and shapes to use. To access this module a separate help ('?') button should be added to the screen (perhaps in one of the bottom corners, see (i) in Figure 4.4), which when accessed pops up a separate window which contains the training module (see (ii) in Figure 4.4).

- Provide users with the choice of having navigational (i.e. next and previous slide) buttons on-screen. A suitable location for these might be at the bottom centre of the screen (see Figure 4.5).

  Having the buttons located here, rather than on the left- or right- hand side of the screen means that the user does not have to reach to one side of the screen to access the buttons. Providing these buttons means that the users are not forced into using the gestures if they do not wish to.

  Unfortunately, this will mean that the users will need to take the existence and placement of the buttons into account when preparing their presentations and that additional use of the screen, e.g. for annotations, will be restricted to a slightly smaller area. Further, the users may need to move to a position more suitable for using the buttons whenever they wish to move to the previous or the next slides.

- Set an area of the screen, say the bottom of the screen, aside for drawing gestures (see Figure 4.6).

  This could allow for a little more flexibility for the users when they draw a gesture. For example, if they draw a next or previous slide gesture with a too large a shaped arrowhead the software should recognise it properly.

  Unfortunately, this will mean that the users will need to take the gestures area into account when preparing their presentations and that additional use of the screen, e.g. for annotations, will be restricted to a smaller area. Further, the users may need to move to a position more suitable for using this area whenever they wish to use a gesture.

- Provide an undo (and possibly redo) gesture to remove unsuccessful strokes. This means that the user can remove unrecognised and unwanted strokes from the slide, minimising the clutter on the slide.

  The suggested gestures (for undo see (i); for redo see (ii)) are given in Figure 4.7.

*Design Recommendation: Make Modes Clearer*

We recommend that modes should be explicitly recognised in the interface design. The different states ('ready' and 'not ready') should be indicated clearly and distinctly by providing some form of feedback to the users. Thus, it is less likely that the users will experience problems while the system is in a 'not ready' state. One way of achieving this is to add different sound effects. Another way is to change the colour of the windows.

*Design Recommendation: Remove the Delete Gesture*

We offer a range of recommendations.

- Make the software work with the Mimio™ eraser. This has two contact areas: a small and a large pad (see Figures 2.6 and 2.7). Using this tool would be more analogous to using a whiteboard duster. Further, the Mimio™ eraser can be developed and incorporated as part of the LIDS pen, so that it is more like a pencil i.e. writing point (lead) at one end and eraser at the other.

- Incorporate an undo mechanism (see Figure 4.7), so that if the user erases a greater areas than is required, then the user can undo the last action and try again. This should provide users with added flexibility and control.

- Enable existing and saved material to be removed. Again, this should provide users with added flexibility and control.

*Design Recommendation: Incorporate Better Anti-Aliasing*

We believe that the users' ability to annotate or write on the screen directly where the text is to be placed with hand written text a significant benefit to the user. As noted in the Technology in Use for Teachers and Students study (see part 3 of this report), this meant that additions were highlighted against the prepared material, focusing the users' work. Thus, to suggest that some form of hand writing recognition technology be adopted would work against that benefit—although, having the choice of which mode to work in would provide greater flexibility for the users.

In terms of the problem with the size of the text, perhaps the issue could be at least partially improved by having better anti-aliasing.

*Design Recommendation: Better Sensitivity of Software*

At one stage, one participant tried to draw a dot on the screen. This was not registered by the software. Instead, the participant had to use a small coloured-in circle in place of a dot. Two participants experienced difficulties trying to join lines that did not meet. We are a little unsure as to what to recommend for this problem. Perhaps, the software could be a little more sensitive in what it recognises.

*Design Recommendation: Add New Interactive Options*

We recommend that the following features be incorporated into the software:

1. A copy gesture that copies the existing drawing and text on a slide to the computer clipboard. This gesture can be extended so that users can select a portion (i.e. either a part or the whole) of the slide and copy this onto the clipboard. The suggested gestures are given in (i.a) for entering the copy mode and (i.b) for selecting a portion of the screen, of Figure 4.9.
2. An insert gesture for manually inserting a slide after the current slide. The suggested gesture is given in (ii) of Figure 4.9.
3. A paste gesture that pastes what is currently on the computer clipboard onto the current slide. The suggested gesture is given in (iii) of Figure 4.9.
4. A gesture to enable the user to go directly to the first slide in the presentation. The suggested gesture is given in (iv) of Figure 4.9.
5. A gesture to enable the user to go directly to the last slide in the presentation. The suggested gesture is given in (iii) of Figure 4.9.

   If providing buttons at the bottom of the screen (as suggested for the next and previous slides above), then the actions i.a, ii, iii, iv, v should also be represented as buttons (see Figure 4.10). The action i.a places the software in a copy mode, i.b should still be used as a gesture to select the area of the slide to copy.

**The Shadow Technology**

*Design Recommendation: Improve On-Screen Shadow*

We recommend that the resolution or graininess of the image and lack of smooth edges be improved.

**The Physical LIDS Technology**

*Design Recommendation: Redesign/Re-Engineer the Mimio™ Pen*

We recommend that the shape of the pen be altered to better represent a whiteboard pen, which is narrower along all parts of the pen (see Figure 7.3). As the participants of the studies and most of the other users we have observed have used the LIDS pen with pre-used whiteboard pens with ink that has run out in place of the plastic pen that comes with the Mimio™ pen, we suggest that the nib be similar to that of a whiteboard pen.

To make changing the battery easier for the user, we recommend that the position of the battery be moved to the end of the re-designed pen (see Figure 7.4). Access can be given by enabling the user to unscrew the pen three-quarters of the way up the pen (near the end), allowing the users to easily access, extract and insert batteries (see Figure 7.5). The position of this access should not hinder use of the pen.

We further recommend that the current Mimio™ pen and eraser be combined into one tool by attaching an eraser to the end of the pen, akin to a pencil with an eraser on the end (see Figure 7.8). Issues regarding the size of the eraser may be solved by enabling the users to place the eraser end of the pen on the screen. If they require a larger eraser than that on the end of the pen, then they need to keep pressure in the same position on the screen. As they do so, the area around the eraser point is erased and the erased area grows larger with the application of the pen in the one position.

We recommend that an easy toggle feature be incorporated with the pen. The toggle feature must be easy to access but must not inhibit the use of the pen by being in the wrong place i.e where the users will typically hold and write with the pen. We suggest a little button, reachable by one of the user's fingers that sits on top of the pen, may be the best position. The suggested placement is given in Figure 7.9.

*Design Recommendation: Enable Easier Access to the Computer Keyboard*

We recommend that the computer keyboard be better physically located to the screen. We suggest that it might be placed on a retractable and rotating keyboard holder (i.e. one that is attached to the bottom of the LIDS), so that users can move it to a more comfortable and useful position (see Figure 7.10).

# Appendix 1. Usability Principles

The following principles have been adopted from Nielsen, 1994.

*Visibility of System Status*

The system should always keep users informed about what is going on, through reasonable feedback within reasonable time.

*Simple and Natural Dialogue*

The system interface should be simplified as much possible. It should speak the users' language with words, phrases and concepts familiar to the user, rather than system-oriented terms and processes.

*User Control and Freedom*

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo. This includes returning to a screen with it in a state users would expect.

*Consistency and Standards*

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

*Error Prevention*

Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

*Recognition Rather Than Recall*

Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

*Flexibility and Efficiency of Use*

Accelerators—unseen by the novice user—may often speed up the interaction for the expert user such that the system can cater for both inexperienced and experienced users. Allow users to tailor frequent actions.

*Aesthetic and Minimalist Design*

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

*Help Users Recognise, Diagnose, and Recover from Errors*

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

*Help and Documentation*

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

The following principle has also been included for this report:

*Missing Features*

The system should include features that the user requires to complete their tasks effectively and efficiently.

# Appendix 2. Usability Testing Collaborative Technologies

### Background: What is a Collaborative Technology?

Computer-based collaborative technologies are those that support the needs of a 'group' using a computer-based technology, where a 'group' constitutes two or more individuals with a shared goal. Collaborative systems do this by facilitating communication and interaction between the group members.

An ideal collaborative system enables each user to gain a sense of satisfaction whether individually or when working within a group. To do this, designers of a collaborative technology must take into account:

- The users of the system e.g. who they are, what their past experiences have been, what their level of expertise is, and so on.[A2.1]
- The goals of the users, at an individual and group level.
- The communication and/or task related activities the users will be required to carry out in order to satisfactorily meet their goals. [A2.2]

(These are similar elements to those for non-collaborative (i.e. single-user) systems. The two elements that are different are the goals of the users at a group level, and the communication related activities of the users.)

The elements, above, must be adequately supported by:

- The individual system entities i.e. tools and objects, which the users will be expected to use to carry out their activities. [A2.3]

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[A2.1] In a collaborative setting, users are 'individuals-in-a-team' (Hughes *et al.*, 1994), but still maintain different perspectives, expertise, and problem solving strategies (Bannon and Schmidt, 1991). Collaborative systems must not only enable and facilitate a range of different attitudes and abilities but must also enable group members with common, multiple, and, possibly, contradictory interests to communicate, solve problems, and make decisions together. In doing so, collaborative systems must take into account and adequately support social presence, and consequently, social protocols. Social presence or awareness involves users being aware of each other and each others' plans and activities when using the system. Social protocols are the day-to-day interruptions, suspensions and resumption of work and its associated processes (Rodden *et al.*, 1997), which are typically inherent within group collaboration.

Both social presence and protocols should be reflected in the ecological nature of the system. Ideally this information should be easily accessible to all users, and portrayed in such a way as to enable the users to be aware of other users' activities and co-ordinate their work appropriately (Rodden *et al.*, 1997).

[A2.2] Taking into account the domains and organisational contexts within which they will be used, collaborative systems should support as-wider range of activities (with regard to the overall purpose of the system) as possible. Group interfaces or work spaces must be developed with different objectives than those for single-user interfaces, as they must support group activity and enable multiple users to control objects and features at the same time.

[A2.3] System entities or tools can be designed to support (i) either same time (*synchronous*) and/or different time (*asynchronous*) and (ii) either same place (*co-located* or face-to-face) and/or different place (*distributed*) collaboration, co-operation, or conflict. Most collaborative tools support synchronous distributed collaboration.

- The entire system, which must merge all the various elements and entities into one working and seamless system.

**Background: What is Usability Testing?**

Usability or user testing is a human-computer interaction (HCI) approach that focuses on the users of a system and how they use the system in question. The general goal of usability testing is to see what usability and functionality issues arise, and feed the results of the study back into the design process. A usability study can be used to help validate the designers' assumptions about the users and how they use the system, and to co-ordinate and drive further system design and development work.

## A2.1 The Goals of Testing the Usability of Collaborative Technologies

At a basic level, the goals of testing the usability of a collaborative technology are the same for testing a single-user (non-collaborative) technology. From the perspective of the researcher, a usability study should focus on:

- The suitability of the individual entities in relation to the purpose of the entire system.
- The utility or usefulness of the entire system, and within that, the individual entities, in meeting the goals of the users.
- The efficiency of the system in allowing the users to satisfactorily meet their goals.
- The affect of the system on the users and their satisfaction in meeting their goals.

For the entire system and each of its individual entities, a usability study should also aim to determine, from the users' perspective:

- The ease of learning the system (is there a low or steep learning curve? how can the users be adequately supported if the system has a steep learning curve?)
- The ease of use (do the users become frustrated with the system or are they able to understand the way it works?)
- The ease of remembering how to use the system (is it easy to remember how things work or must the users continuously look for help?)
- The ease of recovering from errors (do the users find it relatively easy to determine what went wrong and how to find a solution?)
- The enjoyment the users felt when using the system (do the users like the way the system is presented and how it acts?)

Additionally, Ross et al., (1995) indicate that the following experiences of users of a collaborative system should also be investigated:

- Feedback and awareness: the users' awareness of what they are able to do within the system and what the affect of these actions will be, and each user's awareness of each other and each other's actions and the consequences of these actions.
- Communication: the communication processes that are involved with performing the tasks and whether these have been adequately supported by the technology. (Note: communication may be explicit—direct between the users—of peripheral—derived from the users' actions.)
- Focus: the way that changes and/or other users' actions are presented by the technology, and ensuring that these are not overwhelming.
- Co-ordination, ownership and control: the way the technology provides for and supports social protocols e.g. ownership, permissions, precedences, and so on.

- Mental models and metaphors: the users' view or model of how the technology should support the users' tasks and collaborative goals, and whether this matches the metaphoric applications within the system.
- Consistency: the way functions and metaphors are preserved with the system, and whether these are seen as being consistent within the entire system.

## A2.2 What is Studied During a Usability Test of a Collaborative Technology

During a usability test of a collaborative technology the entire system may be the main focus. Alternatively, an individual element or entity, or part of an individual element or entity, within the system may be studied. The focus of the study will depend on the developmental progress of the system and the purpose of the study. Again, this approach is not dissimilar to that used for a single-user system.

## A2.3 Evaluation Methods and Approaches

Usability testing intersects the quantitative (i.e. cognitive psychology) and qualitative (i.e. sociology, philosophy) sciences. It does so by using evaluation methods from each of these research paradigms.

A typical usability study will involve a user or group of users performing some task(s) using the system under investigation. During the study the performance of the users will often be observed and notes taken (similar to ethnography, a sociology method). At some point during the study the users may also be asked to complete a questionnaire (a psychology method) and also talk about their experiences (similar to ethnomethodology, a sociology method). Of course, other methods also exist, such as the survey or focus group, which are management studies methods.

Results may be analysed across the quantitative/qualitative, objective/subjective quadrant. A range of data may be sought, including the time to complete the task(s), the users' accuracy, the users' subjective rating of the task, the users' subjective rating of the system and the users' comments about the tasks and the adequacy of the system in supporting their goals. The data may be analysed statistically or mathematically, or a deeper insight into the meaning behind the results may be sought.

Not typically adopted for single-user systems, but important for collaborative systems, the usability study may also be used to additionally focus on conversations and interactions (a sociological approach) between the users, and breakdowns (a philosophical approach) between the users and their goals, when the user is forced to focus on the system rather than their tasks.

For example, the usability study may be used to determine the users' satisfaction of the collaboration, interaction and co-ordination that takes place. Specific questions that may be asked include:

- Did the system help or hinder the users' collaboration?
- What types of collaboration took place?
- How well did the users collaborate?
- At what points did the collaboration breakdown?
- Did the users focus more on the tools rather than the tasks?

## A2.4 Expected Outcomes

As described earlier the main goal of usability testing is to determine any usability and functionality issues that arise and to feed the results back into the design process.

Functionality issues may include, but should not be limited to, the suitability, utility/usefulness, efficiency and affect of the system and/or individual entities within the system. Usability issues may include, but should not be limited to, ease of learning, ease of use, ease of remembering, ease of recovering from errors, and user satisfaction.

These issues will feed back into the design (whether at a high or low level) process affecting individual tools, whether task- or communication- related, and ultimately the working and seamlessness of the entire system.

# Appendix 3. Technology in Use for Teachers and Students (Interim Report)

*Prepared by Laurie McLeod (University of Waikato Usability Laboratory)*

## A3.1 Introduction

This report has been prepared by Laurie McLeod of the University of Waikato Usability Laboratory (Usability Laboratory) for Mr Bill Rogers and Dr. Masoodian of the Computer Science Department, University of Waikato. Mr Rogers and Dr. Masoodian are the developers of the shadow technology used in conjunction with the Large Interactive Display Screen (LIDS).

This report is provisional only, owing to time constraints and the fact that not all of the data collected has been interpreted and analysed. It presents preliminary results of aspects of a usability study conducted at the Usability Laboratory into the use of the LIDS product in a classroom situation between 21January and 25 January, 2002.

The main purpose of the study is to explore the collaborative support for an interactive group within classroom situation where LIDS is used as the predominant information display and interaction medium. There are two aspects to the study: the effectiveness of the LIDS product as a tool for classroom-based learning and the effectiveness of the product as a learning reference tool. Both of these aspects will be considered in this report.

## A3.2 Method

Participants in this study were students in the summer school course 0657.209S "Object Oriented Programming". The lecturer for the course was Mr Bill Rogers. The study was conducted over three days, during the third week of lectures (see Table A3.1).

The study consisted of three sessions or lectures. The first lecture (one hour duration) was a standard lecture presentation using a prepared PowerPoint™ presentation, a lecture handout, and some sample program files (that were run on the computer). The LIDS screen was used as a projection screen to display the PowerPoint™ presentation, and to display the programs as they were run. The lecturer wrote on the whiteboard in the room and on the LIDS screen with a standard whiteboard pen. The pen markings were erased off the LIDS screen with a duster.

The second lecture (two hours duration) consisted of a prepared PowerPoint™ presentation delivered using LIDS technology (the pen and associated software). There was a lecture handout that the lecturer referred to during the lecture. At the beginning of the lecture, the lecturer also ran a program (on his own computer) that he projected onto the LIDS screen for display. During the lecture, the lecturer was able to move from slide to slide using the LIDS pen and gestures identified by the LIDS software. The lecturer added notes to the PowerPoint™ presentation as the lecture progressed by writing on the LIDS screen with the LIDS pen. These annotations were saved as part of the presentation. The lecturer wore a headset and what he was saying was saved as part of the lecture presentation.

The third lecture (one hour duration) was intended to be delivered using the LIDS technology. It began with a prepared PowerPoint™ presentation delivered using LIDS technology (the pen and associated software). However, about half way through the lecture, problems were experienced with the LIDS software which meant that the PowerPoint™ presentation had to be abandoned for a standard lecture format. The projector was turned off and the lecturer continued the lecture using the LIDS screen as a whiteboard.

| *Session* | *Lecture presentation* | *Duration* | *Day* | *No. of participants** |
|---|---|---|---|---|
| 1 | Standard | 1 hour | Monday | 21 |
| 2 | LIDS technology | 2 hours | Thursday | 24 |
| 3 | LIDS technology | 1 hour | Friday | 12 |
| ** Derived from number of questionnaires completed* | | | | |

*Table A3.1 Experimental design for the 3 sessions*

The study was conducted in the group user room, which was specifically set up to accommodate a lecture with the LIDS screen situated at the front of the room. There were three cameras placed for observation of the lectures. One camera was positioned to view the LIDS screen from directly in front of the screen. The other two cameras were positioned at an angle in front and to the either side of the LIDS screen. A scan converter was connected to the slide projector in order to collect the output from the computer, enabling recording of what was being presented on the LIDS screen.

A quad splitter was used to combine the four images, which were then arranged to display the LIDS screen in the top left hand corner, the camera image of the screen from the left (facing the screen) in the top right hand corner, the camera image of screen from the right (facing the screen) in the bottom left hand corner and the camera image directly in front of the screen in the bottom right hand corner.

At the beginning of the first session participants were given a brief overview of the purpose of the study. Each session began with an initial questionnaire. For the first session participants were asked questions relating to demographic information and their previous learning experiences in the classroom environment. For the second and third sessions, participants were asked about their experiences reviewing the material delivered in the previous session. The main part of the session consisted of the lecture delivery. Each session concluded with a summary questionnaire about the participants' experiences with the lecture.

Participants were asked to complete two questionnaires during their Monday lecture in the week following the study. The first questionnaire (initial questionnaire) asked participants about their experiences of using the LIDS technology to review the material delivered in the LIDS lecture (session two). The second questionnaire (summary questionnaire) asked participants about their feelings about the LIDS technology as an educational tool.

Observations of each session involved note-taking during the sessions, observation of the video tape recordings of each session, and review of the eight questionnaires completed by each participant.

The online material consisted of the PowerPoint presentation, annotations and the audio recording from the lecture. The audio recording for each slide was divided into multiple files that could be accessed by clicking on the audio bars at the bottom of the slide.

## A3.3 Results

The following sections present the results of the part of the study concerning the LIDS technology as a teaching tool. These include participants' experiences with the LIDS technology as a lecture presentation tool or as a lecture review tool, and features about the LIDS technology that they liked and disliked. This analysis focuses on comments made by participants in the questionnaires. Various comments that participants made about the LIDS technology are presented in first appended list (below).

**Participant Experiences of LIDS as a Lecture Presentation Tool**

In session two of the study, a lecture was delivered to participants using the LIDS technology. The comments written by participants in the summary questionnaire to this session have been used to obtain information about participants' experiences with the LIDS as a lecture presentation tool. These comments have been broadly divided into benefits and difficulties associated with LIDS as a lecture presentation tool.

Four participants commented on the benefits of the lecturer being able to annotate the prepared PowerPoint™ presentation. These benefits included the clarification or explanation of the lecture notes, incorporating student-initiated discussion, and highlighting important material. Four participants commented on the way that the LIDS technology integrated lecture content into the one location, making it easier to follow what is going on. One participant felt that the LIDS technology was easy to use and help them to understand material more easily. Three participants commented on how the LIDS technology facilitated teaching by the lecturer. Four participants referred to the novelty value of the LIDS technology.

Four participants commented that they found no difference between the LIDS lecture presentation and other teaching presentation tools.

Six participants commented on difficulties associated with the visibility of the lecture presentation on the LIDS screen. For example, they found the screen to be blurry, difficult to see, or highly reflective. Two participants found the pencil image on the screen distracting. One participant noted that the lecturer had difficulties with correcting some mistakes. Another participant commented on the way that parts of the slides were missing or cut off in the PowerPoint™ presentation.

In session three of the study, only the first half of the lecture was delivered to participants using the LIDS technology. Because of problems experienced during the lecture, the lecturer told participants not to complete the summary questionnaire.

Four participants completed the summary questionnaire of session three. Of these, two participants made no comments. The comments made by the other two participants just reiterated the comments they had made in the summary questionnaire to session three. Their comments have not been evaluated any further.

In question four of the summary questionnaire given to participants on the week following the study, participants were asked to rate, from a student's perspective, LIDS as a lecture presentation tool against other lecture presentation tools using a four-point scale (no experience with the presentation tool before, LIDS not as good as the presentation tool, LIDS same as the presentation tool, LIDS better than the presentation tool). Not all participants completed this question.

The responses are summarised in Figure A3.1. As can be seen, LIDS rates at least as highly as the other presentation tools in most instances. All participants who have experienced the blackboard as a lecture presentation tool consider LIDS to be the better presentation tool. All participants who have experienced the overhead projector (OHP) as a lecture presentation tool consider LIDS to the same, or better than, an overhead projector. All but one participant found LIDS to be the same, or better than, either the whiteboard or a PowerPoint™ presentation as a lecture presentation tool.

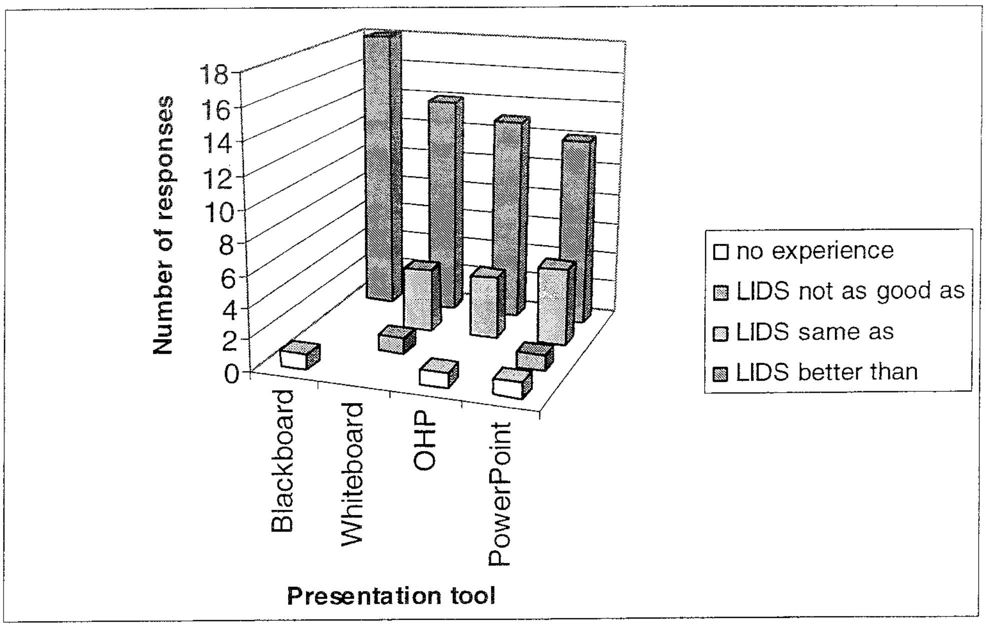


*Figure A3.1 Participants' evaluation of LIDS as a lecture presentation tool*

In addition, three participants commented that LIDS was more advanced than the other presentation tools. Another participant noted that LIDS combined the basic attributes of the other presentation tools. One participant explained that LIDS was a better presentation tool than a blackboard, a whiteboard or a PowerPoint presentation because you can add notes to it, and the same as an overhead projector where you can add notes.

**Participant Experiences of LIDS as a Lecture Review Tool**

In session two of the study, a lecture was delivered to participants using the LIDS technology. This lecture was made available for participants to access in their own time via the Internet. Participants were asked about their experiences using the LIDS technology for this review purpose in the initial questionnaire for session three and the initial questionnaire completed on the Monday following the study.

Ten participants completed the initial questionnaire for session three. Of these, three participants said they had used the review facility. There were problems with the lecture presentation online. For this reason, these questionnaires have not been reviewed in depth.

One participant commented on the value of the review facility, particularly for international students:

> *"can review multiple times... very useful for students, especially for foreign students, because [their] English is not good enough to understand every word the teacher said in class. To review in this way is good for them."*

Question 12 of the initial questionnaire of session 3 asked participants if they would use the review facility if it were available in the future. Of the 10 participants who completed the survey, 7 participants said they would use the review, and 3 participants did not answer this question.

Twenty-three participants completed the initial questionnaire conducted in the week following the study. Of these, 18 participants said they had reviewed the LIDS lecture presentation online, and 5 said they had not.

Most of the participants who had reviewed the lecture presentation online had done so in order to review what was covered in the lecture or to review particular areas they had not fully understood. Three participants said they had reviewed the material to see how LIDS review facility worked.

Of those who had not reviewed the lecture, the main reasons for not reviewing the material were they had been too busy or their Internet connection was not working.

Question five of the initial questionnaire asked participants how long they spent reviewing the lecture material online. Of those who accessed material online, the length of time they accessed the material varied from 10 minutes to 4 hours as shown in Figure A3.2.

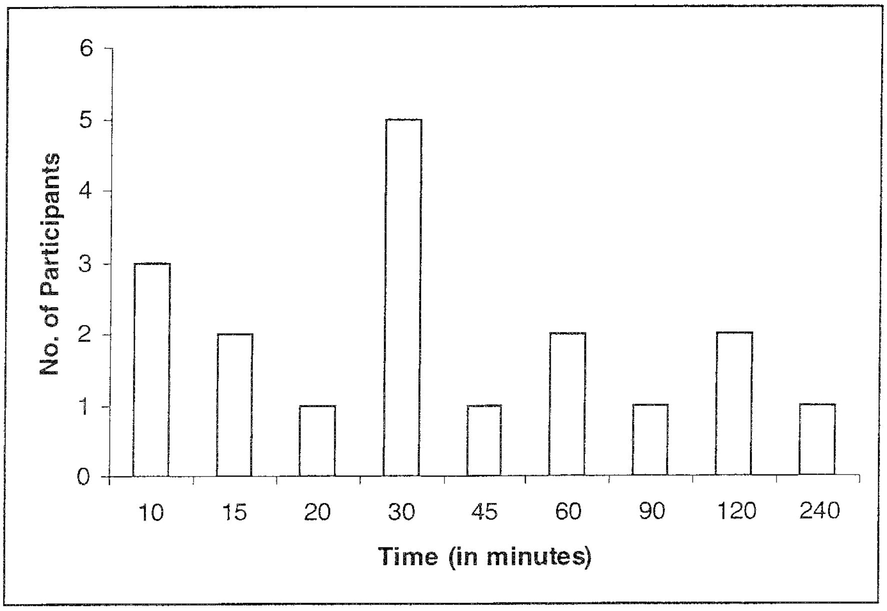


*Figure A3.2 Time spent by participants reviewing the LIDS presentation online.*

Questions four and seven of the initial questionnaire asked participants whether they had any problems accessing or reviewing the online material (respectively). Fifteen participants said that they had no difficulty accessing the material online. Three participants said that they did experience difficulty accessing the online material. Two of these commented that the files were too slow to download.

Ten participants said that they had difficulties reviewing the material online. These difficulties related to the slow downloading of files and the poor quality of the audio content of the presentation.

Question six of the initial questionnaire asked participants whether they found the audio and video content to be clear. Ten participants said they found the audio and video content to be clear, while six participants said that they did not.

There is a more or less direct correlation between how long participants spent reviewing the material online and the comments they made about how difficult/easy they found the material to access and review and what difficulties they experienced with the sound content of the presentation. The participants who expressed frustration over the time taken to download files and the quality of the audio content of the material tended to view the online material for less time. Those participants who spent longer than 60 minutes reviewing the material had few complaints with the material as it was, apart from the audio quality.

Question 11 of the initial questionnaire asked participants whether they felt that, after reviewing the lecture material online, they had learnt anything additional to what they had learnt in the lecture itself. Six participants felt that they had not learnt anything additional to what they learnt in the lecture itself.

Twelve participants felt that they had learnt something in addition to what they had learnt in the lecture by reviewing the online material. Seven of these participants attributed this to the audio content of the presentation. Four participants said that listening to the material again (sometimes multiple times) helped to clarify concepts not fully understood in the lecture. Three participants said that it enabled them to hear things they had missed or forgotten.

Question 12 of the initial questionnaire conducted in the week after the study asked participants whether they would use the review facility of the lids technology at some stage in the future if it were available. Of the 23 participants who completed this questionnaire, all but 1 participant said that they would use the review facility if it were available. Even the participants who had not accessed the material online could appreciate the potential benefits offered by the review facility. Participants said they would use the review facility to clarify concepts not fully understood in the lecture, to cover material that they had missed in the lecture, or to review the entire lecture.

The participant who said that he would not use the review facility had experienced difficulties reading the LIDS screen in class and had difficulty with the audio clips when reviewing the lecture material online. He said:

> *"I strongly recommend not to use it. TERRIBLE".*

As in the preceding section, participants' comments made in the initial questionnaire conducted in the week after the study have been analysed. They have been divided into benefits and difficulties associated with LIDS as a lecture review tool.

Many participants felt that the ability to review the lecture presentation online was beneficial (Table A3.2). The most frequently identified benefit was the ability to access material missed in class. Other participants found the review facility useful in reinforcing or improving their understanding of the material covered. The flexibility to review material multiple times and at the participant's own pace were also mentioned. The audio was identified as a useful feature generally, and specifically in reinforcement and understanding of the material reviewed. One participant noted that lecture presentation provided another means of obtaining information about the study subject.

| *Benefits* | *No. of comments* |
|---|---|
| Access missed material | 7 |
| Reinforcement of material | 5 |
| Flexibility of review | 3 |
| Audio on slides useful | 4 |
| Other | 1 |

*Table A3.2 Benefits of reviewing the LIDS lecture presentation online.*

A number of participants experienced difficulties reviewing the material online (Table A3.3). The majority of the problems related to technical aspects of the online lecture presentation. The most commonly identified problem was the nature and quality of the audio component of the online presentation. Examples identified included: no audio in the laboratories, the audio was not clear, some audio bars had no sound, sometimes words were missing, and the audio clips finished part way through a sentence. Other important technical issues were slow download speeds, and the presentation and location of the annotations. Having many separate audio clips caused difficulties for some participants, including breaking continuity.

| *Problems* | *No. of comments* |
|---|---|
| Audio content | 8 |
| Slow download | 5 |
| Presentation and location of annotations | 2 |
| Separate audio clips | 4 |

*Table A3.3 Problems encountered reviewing the LIDS lecture presentation online.*

**Features That the Participants Liked and Disliked**

Question two in the summary questionnaire conducted in the week following the study asked participants to list three things they liked about the LIDS technology. Not all respondents provided three responses. The responses to this question are summarised in Table A3.4 and an analysis of the responses is presented below. Many of the responses reinforce participants' comments presented in the sections above.

Features that participants liked fell into three categories related to lecture presentation, lecture review and general comments. In the lecture presentation, participants appreciated the ability for the lecturer to annotate the prepared lecture notes. They liked that it integrated everything in one place and that it saved the additional notes. They felt it was easy for the lecturer to write to the screen and to erase annotated material from the screen. Some participants mentioned that it was easy for them to distinguish the hand-written notes. Four participants felt that it improved interaction, for example by enabling the lecturer to incorporate student-initiated discussion or to point things out.

In regards to lecture review, six participants liked the ability to replay the lecture and review the material covered. The audio recording of the lecturer was also highlighted by six participants. Two participants liked the online availability and accessibility of the lecture material. Three participants appreciated that the online lecture presentation enabled them to access material missed in the lecture. They expressed this as being useful if they missed a lecture or parts of material covered in a lecture.

In general, four participants liked that the LIDS technology was easy to use. Two participants liked that it was clear. One participant liked that the way in which everything was integrated in one place. Another participant thought that it was novel.

Question three of the summary questionnaire conducted in the week following the study asked participants to list three things they disliked about the LIDS technology. Not all respondents provided three responses. An analysis of the responses to this question is presented below and summarised in Table A3.4. Many of the responses reinforce participants' comments presented in the sections above.

Features that participants disliked related to aspects of lecture presentation or lecture review. The aspects of the LIDS technology that participants most frequently disliked related to the readability of the lecture presentation on the LIDS. Comments included the screen was hard to read (when seated at an angle to the screen or when the background light was high), the screen was too reflective or bright, and the screen was too small. Five participants commented on the technical instability of the

LIDS software. They disliked that it was not stable enough, or that it crashed or was too slow. Two participants found the pen annoying. Another two participants found the pencil image on the screen distracting. Other participants commented that the LIDS technology was awkward in its use in the class or that it was not interactive.

| *Likes* | *No. of responses* | *Dislikes* | *No. of responses* |
|---|---|---|---|
| Lecture presentation | | Lecture presentation | |
| Ability to annotate notes | 7 | Screen readability | 9 |
| Easy to erase annotations | 2 | Instability of LIDS software | 5 |
| Improved interaction | 4 | Pen | 2 |
| | | Pencil image distracting | 2 |
| | | Usability in class | 2 |
| Lecture review | | Lecture review | |
| Ability to replay lecture | 6 | Slow to download | 6 |
| Audio recording of lecturer | 6 | Separate audio clips | 2 |
| Online availability | 2 | No video of lecturer | 2 |
| Accessing missed material | 3 | | |
| General | | | |
| Easy to use | 4 | | |
| Clear | 2 | | |
| Other | 2 | | |

*Table A3.4 Participant likes and dislikes.*

In terms of reviewing lecture material online, six participants disliked the amount of time that files took to download. Two participants disliked the way in which the audio content was constructed of separate files (e.g. so that you had to click to hear each sound file). Two participants disliked that there was no video of the lecturer incorporated into the lecture presentation.

**Appended List 1: List of Participant Comments About the LIDS Technology**

This appended list presents a summary of various comments made by participants in completing the questionnaires as part of this study. The comments relate to the LIDS technology, and provide a useful source of quotes to illustrate the results presented in this study.

Each comment has been summarised and grouped thematically.

*LIDS as a Lecture Presentation Tool*

Ability to annotate notes

- Hand written notes useful to jot down as notes
- It helped because the lecturer could add extra text to explain the notes
- Because the teacher can explain more
- Student could ask a question and lecturer could integrate this into the notes
- It can highlight important stuff

Integrated content in one location

- Only one piece of equipment to concentrate on which makes it easy to follow the lecture
- All notes in the same places
- Its not much different to a normal lecture presentation, it is just more concentrated at one point (one board).
- Easy to follow because writing on same screen
- Power point and hand written notes a good combination
- Same screen; no other stuff than PowerPoint presentation and handwriting)
- Able to see how the notes and "whiteboard" markings interacted
- Not distracted by change from 1 media to the other

Facilitated teaching

- The LIDS technology aided the lecturer's teaching of the material
- A natural, convenient way to present
- Visual aid was clear and easy to use)

Novelty value

- It's very interesting
- More flexible
- It's cool
- Novelty value

Other

- It is easy to use, erase, go ahead. It will save time. So it will help me understand material better.

Same as other presentation tools

- I don't think it's a significant improvement over traditional OHPs
- It's just like a lecture where PowerPoint is used
- Its not much different to a normal lecture presentation, it is just more concentrated at one point (one board).
- I found no difference between LIDS and whiteboard
- Visibility of screen
- Sometimes screen difficult to see
- Can't see from the side
- Difficult to view sometimes – mainly difficulties with the screen
- Sometimes difficult to follow what is going on because the screen is small and blurry, difficult to see from the back
- Screen is really reflective and more difficult to see
- I don't think the characters on LIDS are clear enough

Pencil image on screen

- Pencil on screen annoying, covers things up
- Might try to get pencil on the screen out of the way

Other difficulties

- Lecturer had difficulties erasing sometimes
- Parts of the slides on PowerPoint were missing or cut off

*LIDS as a Lecture Review Tool*

Access missed material

- I may have missed something and need to review it
- I can hear some missed important points again
- In a lecture there's only so many notes I can take. I always end up missing something I really need to know about. I can get the stuff missed in lectures
- Sometimes I lose concentration in class, thus it is good to be able to go back and have a look
- I could hear things spoken that I may have missed first time around
- Gave some clarification of concepts I missed during the lecture
- Sometimes you forget something important that was said and now I could go back and listen again

Reinforces material covered

- Listening to the explanation several times helped me to understand material better
- I understood concepts a lot better than I did after the lecture
- It was good to hear parts of the lecture again, because it reinforced ideas
- At times, I didn't understand ideas spoken it lecture, but listening to it again helped to make some of the ideas clear
- makes it easier listening to the explanations again

Flexibility of review

- To go over concepts not fully understood at my own pace
- Having separate sound clips means you can access what you want
- Could review material multiple times

Audio on slides useful

- useful because audio is available on the slides
- audio/video is helpful
- It would be great to have a complete review of lecture, especially the audio
- Having audio to explain notes more is brilliant

Other

- Another means of obtaining information about the study subject

Problems with audio content

- The audio part is sometimes not very clear (2)
- no audio in the labs (2)
- some of the audio sections appeared to have nothing on them
- no sound for some audio bars
- sometimes words missing from some audio bars
- sometimes sound clips finished mid way thru a sentence
- Had difficulty with audio. I lost interest.

Slow download

- audio was very slow
- took a long time to view
- some audio took a while to download
- Takes too long to download

- slow to download wav files

Problems with annotations

- Handwriting areas are rectangles filled with cyan background colour
- Some of the lines on slides came up in different places

Problems with separate audio files

- When I press the sound files, it executes but not continuously. So I have to press again. I don't feel good about that.
- Tedious clicking on different audio sections then waiting to download
- Splitting up the [audio] breaks the continuity and made it hard for me to maintain concentration
- Having separate sound clips, then it is hard to access each bit

# Appendix 4. Interactive Gesture Recognition Tools (Interim Report)

*Prepared by Laurie McLeod (University of Waikato Usability Laboratory)*

## A4.1 Introduction

This report has been prepared by Laurie McLeod of the University of Waikato Usability Laboratory (Usability Laboratory) for Mr Bill Rogers and Dr. Masoodian of the Computer Science Department, University of Waikato. Mr Rogers and Dr. Masoodian are the developers of the shadow technology used in conjunction with the Large Interactive Display Screen (LIDS).

This report is provisional only. It presents preliminary results of aspects of a usability study conducted at the Usability Laboratory into the use of interactive gesture recognition tools and the LIDS between 14 and 18 January 2002.

The main purpose of the study is to inform the developers of the technology of any issues associated with the design of the gesture recognition software and LIDS hardware that may impact on the effectiveness of the intended users' ability to create, edit and navigate a PowerPoint™presentation.

## A4.2 Method

Six participants were involved in the study, three females and three males. Participants were students of the University of Waikato who recruited by advertising posters displayed on various notice boards around Campus. One participant was involved in each session that lasted one hour (see Table A4.1). The gender of each participant is shown in brackets).

| *Session Number* | *Participant Number* | *Length of task (mins)* |
|---|---|---|
| 1 | P1 (F) | 25 |
| 2 | P2 (M) | 23 |
| 3 | P3 (M) | 13 |
| 4 | P4 (F) | 10 |
| 5 | P5 (F) | 25 |
| 6 | P6 (M) | 23 |

*Table A4.1 Participants in each session of the study.*

The study was conducted in the group user room, which was specifically set up to accommodate someone delivering a PowerPoint™presentation to an audience using the LIDS screen, which was situated at the front of the room.

Creating and editing the PowerPoint™presentation entailed the use of specifically designed gesture recognition software. There are five gestures available, including:

- **Next Slide** gesture for moving forward to the next slide in the presentation. This entailed the user drawing a horizontal line from left to right on the screen, and then drawing the line back on itself for a distance. (This is analogous to a right-facing arrow in which the arrowhead is very narrow.) Moving forward to the next slide saved any text or drawing that had been added to the slide.

- **Last Slide** gesture for moving back to the previous slide in the presentation. This entailed the user drawing a horizontal line from right to left on the screen, and then drawing the line back on itself for a distance. (This is analogous to a left-facing arrow in which the arrowhead is very narrow.) Moving back to the previous slide saved any text or drawing that had been added to the slide.

- **Delete** gesture for deleting an object on the slide in the presentation. This entailed the user drawing five zigzag lines back and forth over the object in such a way as to create the corners of a box that completely encompassed the object to be deleted. The gesture had to begin in a bottom corner and zigzag upwards. Only text or drawings that had not been saved could be deleted.

- **Erase All** gesture for erasing the contents of the slide. This entailed the user drawing a vertical line from top to bottom on the screen, and then drawing the line back on itself for a distance. (This is analogous to a down-pointing arrow in which the arrowhead is very narrow.) Only text or drawings that had not been saved could be deleted in this way.

- **Finish and Save** gesture for finishing and saving the presentation. This entailed the user drawing a vertical line from bottom to top on the screen, and then drawing the line back on itself for a distance. (This is analogous to an up-pointing arrow in which the arrowhead is very narrow.)

Users had a choice four pen colours with which to write or draw. These were: black, red, blue or green. Pen colour could be accessed by clicking on the Start button in the left-hand bottom corner of the LIDS screen.

There were three cameras placed for observation of the presentation. One camera was positioned to view the LIDS screen from directly in front of the screen. The other two cameras were positioned at an angle in front and to the either side of the LIDS screen. A scan converter was connected to the slide projector in order to collect the output from the computer, enabling recording of what was being presented on the LIDS screen. A quad splitter was used to combine the four images, which were then arranged to display the LIDS screen in the top left hand corner, the camera image of the screen from the left (facing the screen) in the top right hand corner, the camera image of screen from the right (facing the screen) in the bottom left hand corner and the camera image directly in front of the screen in the bottom right hand corner.

Each session began with an initial questionnaire in which the participant was asked questions relating to demographic information and his/her previous experience using PowerPoint. It was followed by a brief training session using LIDS and the gesture recognition tools. The main part of the session involved the participant creating a PowerPoint™presentation using LIDS and the gesture recognition tools. Each participant presented a story, similar to Goldilocks and the Three Bears, incorporating both text and images in their presentation. A drawing of the gestures, which the participants could refer to, was displayed on a whiteboard throughout the session. The length of time taken to complete the task varied between participants (see Table A2.1)

Observations of each session involved note-taking during the session, observation of the video tape recordings of each session, and analysis of the summary questionnaire completed by each participant.

## A4.3 Results

All participants said that they had prior experience using PowerPoint. The following sections present the results of the part of the study concerning the use of the gesture recognition tools. These include observations of the use of the gesture recognition tools, the participants' perceptions of the gesture recognition tools, their experience of using the gesture recognition tools, features about the gesture recognition tools that they liked and disliked, and suggested improvements to the gesture recognition tools. Any comments made by participants in the summary questionnaire are presented at the end of this interim report.

**The Participants' Use of the Gesture Recognition Tools**

The following observations were made by observing the video tape recordings of each session. For convenience, in this section each of the participants is referred to by their participant number (see Table A4.1).

The duration of the task varied for each participant from between about 10 minutes (for P3 and P4) to around 25 minutes (for the other participants). [Refer to Table A4.1 for the actual duration of the task for each participant.]

This section describes the use of each gesture in turn.

*The Next Slide Gesture*

In creating a PowerPoint™presentation, the participant was required to move forward from one slide to the next, or from the most recently created slide to a new slide, using the Next Slide gesture. The number of instances in which each participant tried to move forward to the next slide or to create a new slide (using the Next Slide gesture) during the task is presented in Table A4.2.

In a number of these instances, the participant experienced difficulties in using the gesture, drawing the gesture incorrectly (so that it was not recognised by the software), trying to draw the gesture before the software was ready, or not maintaining contact between the pen and the screen while drawing the gesture (see Table A4.2). Some of these instances involved multiple attempts by the participant before the gesture was successfully deployed.

All of the participants used the Next Slide gesture on multiple occasions, and in doing so most participants experienced few difficulties with using the Next Slide gesture. P1 had no difficulties using the Next Slide gesture, although in a couple of instances she was nearly too fast in trying to perform the gesture before the pen was ready.

P5 and P6 experienced difficulty on only one occasion. In this instance, P5 tried to draw the gesture before the software was ready. P6 drew a horizontal line for the gesture and, aware that the gesture was incorrect, removed the line before moving to the next slide.

P3 had difficulties in two instances, once in not maintaining the contact between pen and the screen and once in not drawing the gesture correctly. Both instances occurred towards the beginning of the task. In the latter instance, the gesture was drawn incorrectly three times before it was successfully recognised by the software: twice the participant used an unusual arrowhead, and then the line in the return direction was too short. The participant tried to remove the extraneous markings before moving onto the next slide. Interestingly, on two separate occasions, P3 unintentionally reproduced the Next Slide gesture while drawing a picture (of a wolf) and while trying to underline some text. On another occasion, while trying to see if he could simulate the Next Slide gesture, P3 intentionally reproduced the Next Slide gesture while underlining some text.

P4 experienced difficulties using the Next Slide gesture in three instances. In each instance, it took three attempts before the gesture was successfully deployed. The main problem encountered was in drawing the gesture: the horizontal line was too curved or the line in the reverse direction formed too wide or too large an arrowhead.

| *Participant number* | *Number of instances gesture used* | *Number of instances difficulties encountered* | *Cause of difficulty* | | |
|---|---|---|---|---|---|
| | | | *Software not ready* | *Gesture drawn incorrectly* | *Pen lost contact with screen* |
| P1 | 15 | 0 | 0 | 0 | 0 |
| P2 | 17 | 8 | 0 | 8 | 0 |
| P3 | *12 | 2 | 0 | 1 | 1 |
| P4 | 9 | 3 | 1 | 3 | 1 |
| P5 | 9 | 1 | 1 | 0 | 0 |
| P6 | 7 | 1 | 0 | 1 | 0 |
| Total | 69 | 15 | 2 | 13 | 2 |

** The participant simulated the gesture on three of these occasions*

*Table A4.2 Use of the next slide gesture.*

One participant (P2) experienced significant difficulty using the Next Slide gesture. In nearly half of the instances that he used the gesture he experienced problems, all related to drawing the gesture. The reasons that the attempted gestures were not recognised by the software include the participant drew an unusual arrowhead, the horizontal line was too curved, the line in the reverse direction formed too wide or too large an arrowhead.

The instances in which the problems were encountered by P2 occurred within the first twelve instances in which the gesture was used. On three of the eight instances in which problems were encountered, the participant took multiple attempts before the gesture was successfully recognised. On one occasion this involved three attempts, and on two occasions he took six attempts, to use the gesture correctly. On the last six occasions in which the participant used the Next Slide gesture, it was used successfully first time, possibly indicating that he had now understood how to draw the gesture correctly.

In summary, most participants were able to use the Next Slide gesture with ease. Difficulties encountered included (in decreasing order): drawing the gesture incorrectly, trying to perform the gesture before the software was ready or breaking the contact between the pen and the screen.

The most commonly encountered problem was in drawing the gesture, where the attempted gesture was not recognised by the software because the gesture was given too definite an arrowhead (which was unusually shaped, too large or too wide) or the horizontal line was too curved. One participant, in particular, had difficulties drawing the gesture correctly, requiring up to six attempts to get the gesture to be recognised. In the end, however, this participant was able to successfully use the gesture on multiple occasions in succession.

*The Last Slide Gesture*

In editing and navigating a PowerPoint™presentation, the participant was required to move back from one slide to the previous slide using the Last Slide gesture. The number of instances in which each participant tried to move back from one slide to the previous slide (using the Last Slide gesture) during the task is presented in Table A4.3. In a number of these instances, the participant experienced difficulties in using the gesture, including trying to draw the gesture before the software was ready or drawing the gesture incorrectly (so that it was not recognised by the software) (see Table A4.3). In all but one of these instances (where it took two attempts before it was successfully deployed), the gesture was successfully deployed on the second attempt at using it.

| *Participant number* | *Number of instances gesture used* | *Number of instances difficulties encountered* | *Cause of difficulty* | |
|---|---|---|---|---|
| | | | *Software not ready* | *Gesture drawn incorrectly* |
| P1 | 11 | 3 | 2 | 1 |
| P2 | 4 | 1 | 0 | 1 |
| P3 | 4 | 1 | 0 | 1 |
| P4 | 4 | 1 | 1 | 0 |
| P5 | 4 | 1 | 1 | 1 |
| P6 | 4 | 2 | 2 | 0 |
| Total | 31 | 9 | 6 | 4 |

*Table A4.3 Use of the last slide gesture.*

All of the participants used the Last Slide gesture on multiple occasions, and in doing so most participants experienced few difficulties with using the gesture. Four participants experienced difficulty in using the gesture on one occasion: P2, P3, P4 and P5. Of these, one participant (P4) tried to draw the gesture before the software was ready and two participants (P2 and P3) drew the gesture incorrectly. The other participant (P5) tried to draw the gesture before the software was ready and then drew the gesture incorrectly. In this latter attempt, the line in the reverse direction was too short. She then went back and tried to extend the length of the line (in the reverse direction).

P6 experienced difficulties using the Last Slide gesture in two instances. On both occasions, he was moving back through successive slides and tried to draw the gesture before the software was ready. In commenting about the Next Slide and Last Slide gestures, he noted:

> *"It was the line thing. When I do that line, if I didn't come back far enough, I just end up with a line ... I had to make sure I came back to there [pointing to about half way] ... You can't go back too far either. It was generally not going far enough in the reverse direction." (P6)*

P1 experienced difficulties using the Last Slide gesture in three instances. On two occasions, she tried to draw the gesture before the software was ready, and on the other occasion, she drew the gesture incorrectly.

In summary, most participants were able to use the Last Slide gesture with ease. Difficulties encountered included (in decreasing order): trying to perform the gesture before the software was ready and drawing the gesture incorrectly. The Last Slide gesture was often used towards the end of the task, when participants were reviewing what they had done. In moving back through successive slides, participants often tried to perform the Last Slide gesture too rapidly in succession without waiting for the software to catch up. Problems in drawing the gesture correctly include: the gesture was given too definite an arrowhead, the line in the reverse direction was not long enough, or the horizontal line was too curved.

*The Delete Gesture*

In editing a PowerPoint™ presentation, the participant was able to remove material from a slide using the Delete gesture. The number of instances in which each participant tried to delete material using the Delete gesture during the task is presented in Table A4.4. In a number of these instances, the participant experienced difficulties in using the gesture (see Table A4.4).

| *Participant number* | *Number of instances gesture used* | *Number of instances difficulties encountered* |
|---|---|---|
| P1 | 7 | 4 |
| P2 | 8 | 5 |
| P3 | 7 | 6 |
| P4 | 4 | 2 |
| P5 | 26 | 16 |
| P6 | *15 | 3 |
| Total | 67 | 36 |
| * *The participant simulated the gesture on one of these occasions* | | |

*Table A4.4 Use of the delete gesture.*

Figure A4.1 shows the distribution of the number of times the Delete gesture was attempted across all of the instances in which it was used. The Delete gesture was used successfully first time in fewer than half of the instances in which participants tried to delete material using the Delete gesture. In other words, in more than half of the instances participants attempted the Delete gesture more than once.

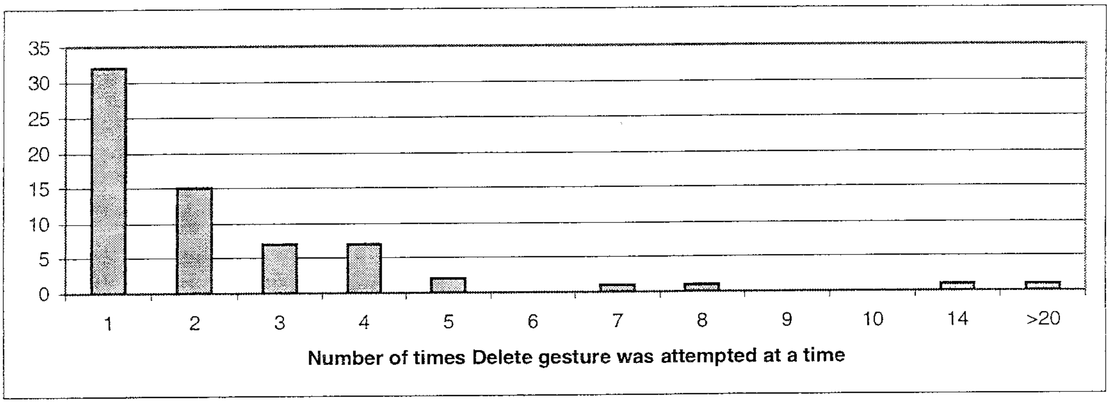


*Figure A4.1 Distribution of the number of times the Delete gesture was attempted at a time.*

This pattern of behaviour is consistent across nearly all of the participants. Five of the participants experienced problems using the Delete gesture in at least half the instances in which they used it (see Table A4.4). Only P6 used the Delete gesture consistently with any degree of success.

In fifteen instances, the Delete gesture was used twice before the material was removed. In seven instances, the Delete gesture was used three before the material was removed. In seven instances, the Delete gesture was used four times before the material the material was removed. In separate instances, one participant (P5) used seven, fourteen and more than twenty attempts at the Delete gesture. Another participant (P2) used eight attempts at the Delete gesture in one instance.

Problems experienced in using the Delete gesture arose because the gesture did not fully enclose the material to be removed, or because the gesture was drawn incorrectly (so that it was not recognised by the software). Participants drew the gesture incorrectly by starting the gesture from the top (rather than from the bottom), by using four back and forth strokes (rather than five), or by drawing the gesture too curved or on an angle. Table A4.5 illustrates the occurrence of some of these problems.

| *Nature of the Problem* | *Occurrence* | *No of participants who experienced the problem* |
|---|---|---|
| Gesture not big enough | *29 | 6 |
| Gesture started at top | 8 | 2 |
| Gesture comprised 4 strokes | *26 | 4 |
| Gesture too curved | 5 | 1 |
| Gesture on an angle | 1 | 1 |
| Pen lost contact with screen | 1 | 1 |
| * *The high incidence observed for these problems attributable mainly to one participant.* | | |

*Table A4.5 Problems encountered using the Delete gesture.*

The multiple attempts at using the Delete gesture can be accounted for in part by problems experienced in using the Delete gesture and in part by the fact that any attempts not recognised by the software remained on the slide. In some instances, this produced considerable mess on the slide, which the participant usually tried to remove. As one participant put it:

> *"When it doesn't work, it gets progressively worse." (P5)*

In one instance, P3 gave up trying to remove the resulting mess (after five attempts at using the Delete gesture) and, on another occasion, he used the Erase All gesture to remove the material (after one attempt at using the Delete gesture). In two instances, P5 gave up trying to remove the resulting mess (after four and fourteen attempts at using the Delete gesture). In two other instances, she used the Erase All gesture to remove the material (both times after four attempts at using the Delete gesture).

In commenting about the difficulties she experienced using the Delete gesture, P5 said:

> *"I think the deletion. For some reason, I had difficulty getting the right number of strokes. And, as I said, it has to be all encompassing and it's easy to forget that. And it gets progressively worse." (P5)*

Other aspects of the Delete gesture also presented (and may continue to present) problems. The gesture sometimes removed more material than was wanted. For example, one participant commented on not being able to remove just part of what she had drawn.

> *"I can't just delete part of it, can I?" (P1)*

One participant unintentionally simulated the Delete gesture when trying to colour in an object.

Furthermore, the Delete gesture does not remove material that has already been saved. During the training session, one participant tried using the Delete gesture several times in succession to remove material. The gesture should have worked and this puzzled the participant. It took a while before it was realised that she had previously moved off this slide and the back onto it, so that the Delete gesture would not work any way.

In summary, the Delete gesture is more complicated than the other gestures to use. As one participant noted:

> *"I found this going forwards and backwards very easy. This stroke [he does the Next Slide and Last Slide gesture in the air]. To erase something ... takes a bit more time to get used to it. I just need a bit more time to get used to it." (P3).*

The software is specific in its recognition and deployment of the gesture. The gesture must start in a bottom corner, and comprise five zigzag lines back and forth over the object in such a way as to create the corners of a box that completely encompasses the object to be deleted. All but one participant experienced difficulties (to varying degrees) in drawing the gesture correctly, and all six participants experienced difficulties making the gesture large enough to enclose the object to be deleted.

The difficulties experienced in using the Delete gesture may not necessarily be overcome with prolonged use of the gesture. In a related usability study (Technology in Use for Teachers and Students), the developer of the gesture recognition software presented two lectures to a class of students using a prepared PowerPoint™ presentation delivered using LIDS technology (the pen and associated software). During the course of these lectures, he had difficulty using the Delete gesture on a number of occasions (more than six). On most of these occasions, he attempted the Delete gesture more than twice. On one occasion, he then used Erase All to remove the original material and the unsuccessful gestures, while on two other occasions he just left it all on the slide.

*The Erase All Gesture*

In editing a PowerPoint™ presentation, the participant was able to remove the contents of a slide using the Erase All gesture. The number of instances in which each participant tried to remove the contents of a slide using the Erase All gesture during the task is presented in Table A4.6.

Five of the participants used the Erase All gesture, with four participants using the gesture three times. Only in one instance did a participant (P2) experience difficulty in using the gesture (see Table A4.6), when the first attempt at drawing the gesture was not sufficiently vertical or it was given too definite an arrowhead.

Two participants used the Erase All gesture after they had been having trouble using the Delete gesture to remove material. In particular, P5 used the Erase All gesture on three occasions while working on the same slide after she had been having trouble using the Delete gesture. On two of these occasions, this did not result any significant loss of material as she was drawing the first figure on the slide. On the third occasion, however, she had nearly completed the slide when she used the Erase All gesture and lost all that she had drawn. It seemed as if she had use the Erase All gesture to solve her problem with deleting, and had not realised the full implications of the action. Her response on seeing the effect was: "Oh dear, it took so much".

| *Participant number* | *Number of instances gesture used* | *Number of instances difficulties encountered* |
|---|---|---|
| P1 | 1 | 0 |
| P2 | 3 | 1 |
| P3 | 3 | 0 |
| P4 | 0 | 0 |
| P5 | 3 | 0 |
| P6 | 3 | 0 |
| Total | 14 | 1 |

*Table A4.6 Use of the Erase All gesture.*

*The Finish and Save Gesture*

In editing a PowerPoint™ presentation, the participant was able to exit the presentation using the Finish and Save gesture. The number of instances in which each participant tried to exit the presentation using the Save and Finish gesture during the task is presented in Table A4.7.

Generally, participants only used this gesture at the end of the task. In addition to this, P5 used the Finish and Save gesture unintentionally when she had meant to use the Erase All gesture part way through the task.

| *Participant number* | *Number of instances gesture used* | *Number of instances difficulties encountered* |
|---|---|---|
| P1 | 1 | 0 |
| P2 | 1 | 1 |
| P3 | 1 | 0 |
| P4 | 1 | 0 |
| P5 | *2 | 1 |
| P6 | 1 | 0 |
| Total | 7 | 2 |
| * *On one occasion, the participant used the Finish and Save gesture when she should have used the Erase All gesture.* | | |

*Table A4.7 Use of the Finish and Save gesture.*

In two instances, participants (P2 and P5) experienced problems using the Finish and Save gesture. It was not obvious what the source of P2's problem was, but it did take two attempts before the gesture was deployed successfully. At the end of the task, P5 mistakenly used the Erase All gesture (which she did incorrectly) instead of the Finish and Save gesture. She checked the list of gestures displayed on the blackboard before using the Finish and Save gesture successfully.

One participant (P1) commented that:

> *"[I]t felt strange to draw [the Finish and Save gesture] up through the middle of the picture".*

A technical problem was noted by one participant (P6) using the Finish and Save gesture. At the end of the task, he reviewed his presentation and added some more drawing to an intermediate slide, before using the Finish and Save gesture to exit the presentation. As the presentation closed, it appeared to remove the additional drawings he had done. When we opened the presentation, the additional drawings had not been saved as part of the presentation. In the words of the participant:

> *"It's not Finish and Save. It's just Finish." (P6)*

*Pen Colour and Other Aspects*

Five of the participants changed the colour of the pen during the task (see Table A4.8), with two of the participants changing pen colour multiple times. At times during the task, the Start button, which incorporates the menu containing the pen colour options, was not visible. It seemed to appear and disappear at different times without any apparent pattern. At least one participant commented on this.

| *Participant number* | *Number of times pen colour changed* |
|---|---|
| P1 | 1 |
| P2 | 5 |
| P3 | 0 |
| P4 | 6 |
| P5 | 1 |
| P6 | 2 |

*Table A4.8 The use of pen colour.*

Another aspect of the technology that participants noted was the size of the text and restrictions this presented in doing the task. At the beginning of the task, one participant (P6) remarked on the size of the writing produced by the pen on the screen. He said:

> *"You wouldn't want to write too much ... or couldn't fit too much writing on there. Or I couldn't." (P6)*

Another participant (P5) chose to write all of the text in the presentation in block case to improve the legibility.

At one stage, one participant (P5) tried to draw a dot on the screen. This was not registered and she had to use a small circle that she coloured in. Two participants (P1 and P5) experienced difficulties trying to join lines that did not meet.

When asked about this and writing on the screen, P5 said:

> *"I did actually find it hard ... It doesn't flow as easily as drawing images ... The text was a little more difficult, but you have to remember to apply consistent pressure ... otherwise you run into problems."*

One participant (P1) reviewed her PowerPoint™ presentation after the task was completed. She appreciated what had been created, but felt that the presentation should not have incorporated all of the slides that she had navigated through when she made the presentation. She also commented about not being aware that some of the unsuccessful attempts at gestures (particularly the Next Slide and Last Slide gestures) had left artefacts that she would have removed at the time had she been aware of them.

One participant (P2) had trouble relating his story to us and completed the last half of the task using Chinese characters and pictures. It was noted that some of the characters he used appeared to be similar to some of the gestures.

**The Participants' Perceptions of the Gesture Recognition Tools**

Question 11 in the summary questionnaire asked participants to use a 7-point scale to record their feelings about 6 aspects of the gesture recognition tools. Each scale consisted of a pair of extremes: complex – simple, low tech – high tech, unreliable – reliable, complex to use – easy to use, unfriendly – friendly, dislike – like. In our data analysis we have assigned a value of 0 to the midpoint of each scale, negative values moving towards the left-hand extreme of each pair (-1, -2, -3), and positive values moving towards the right-hand extreme of each pair (1, 2, 3). All participants completed this question.

The distribution of responses for each of the six scales used in question 11 is illustrated below in Figure A4.2. Most participants felt that the LIDS technology was not complex or unfriendly, and that it was reliable and easy to use.

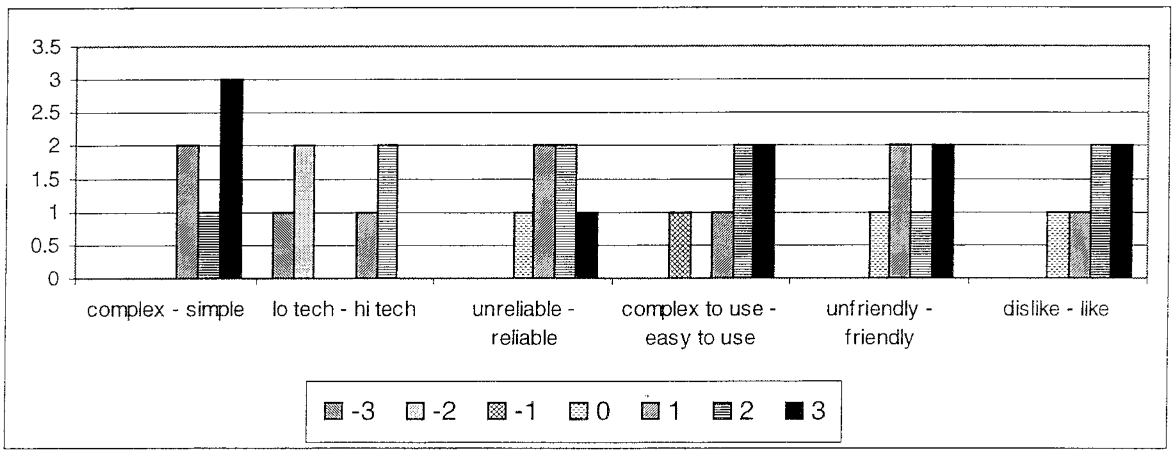


*Figure A4.2 Participants' perceptions of the gesture recognition tools.*

To gauge the overall perception of the gesture recognition tools held by individual participants, we calculated an overall average rating across all 6 aspects for each participant. For 5 participants, the average value across all of the categories was at least 0.8. These participants all liked the gesture recognition tools to varying degrees. The other participant had an average value of 0 and was neutral in her like/dislike of the gesture recognition tools when she evaluated that particular aspect.

**The Participants' Experience of the Gesture Recognition Tools**

The summary questionnaire asked participants a number of questions about their experiences using the gesture recognition tools. Each of these questions asked participants to rate their agreement with a particular statement on a five-point scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree).

The first three questions related generally to the participants' experiences in using the LIDS technology and the gesture recognition tools. These questions were:

> "1. I enjoyed using the LIDS technology and the gesture recognition tools."
>
> "2. In general, I found that I could follow what was going on with ease."
>
> "3. In general, I found that I focussed more on the technology than on the actual task."

The distribution of responses for these questions is shown in Figure A4.3.

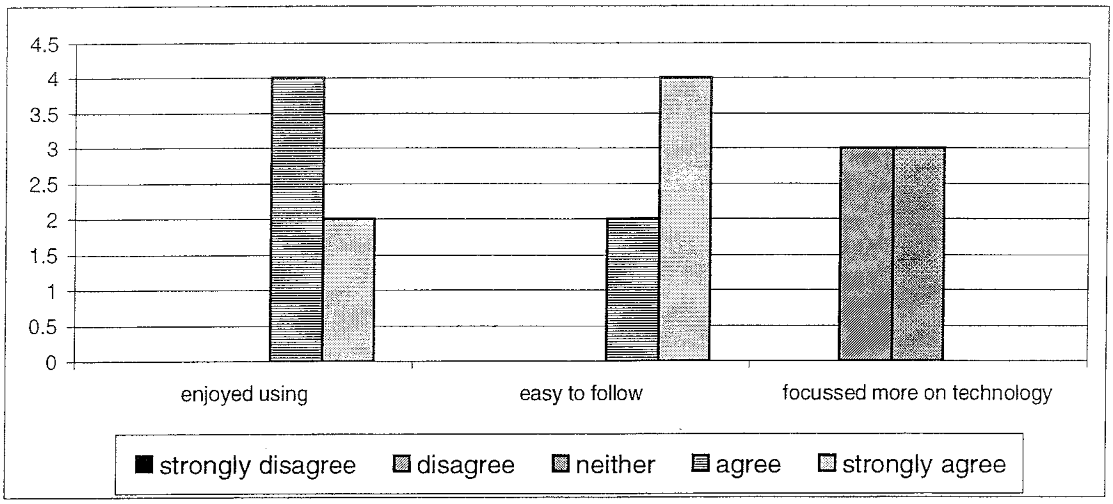


*Figure A4.3 Distribution of responses to questions 1 to 3 of the summary questionnaire.*

All six participants enjoyed using the LIDS technology and the gesture recognition tools to perform the presentation of their story. Three participants commented on the ease to use of the technology in performing the task. Another participant likened it to using a whiteboard. Two other participants felt that it was fun to work on a large surface or to use a pen that never ran out.

The six participants could generally follow with ease what was going on. One participant commented on the fast program response time and that no delay was experienced when writing on the LIDS screen. The other five participants commented that the technology was simple to understand or relatively easy to use. One participant said that it was significantly easier to use than other presentation packages that she has used. Another participant noted that deleting could be tricky at times. Another participant said that he had to make sure that he did not go too fast for the system to keep up.

Three participants said they did not focussed more on the technology than on the task. One participant attributed this to not having to remember complicated commands or strokes. Another participant felt that some degree of thought had to be given to the motions made with the pen.

The other three participants neither focussed more on the technology nor on the task. One participant felt that both the technology and the task were interesting. Two participants said that they focussed on the technology initially and then later on the task, as the novelty of the technology became wore off, or as the gestures became more familiar.

The next five questions related to participant's specific experience using the gesture recognition tools. These questions were:

"4. I found it easy to present my story using the LIDS technology and the gesture recognition tools."

"5. I found it easy to navigate around PowerPoint™ using the gestures that were taught to me."

"6. I found the gestures easy to learn."

"7. I found that with use the gestures became easier to do."

"8. I found that the use of the gestures inhibited my ability to present my story."

The distribution of responses to these questions is shown in Figure A4.4.

Five of the participants found that it was easy to present the story using the LIDS technology and the gesture recognition tools. The sixth participant was neutral about the ease of presenting the story using the LIDS technology and gesture recognition tools, as he found that it was initially difficult until he was familiar with the gestures.

In particular, two participants commented favourably on the ease of using the LIDS technology and the gesture recognition tools to perform the task relative to other media. It was "like using paper and pen" and "easier than using a whiteboard". Another participant liked being able to move from screen to screen and not having to erase what he had written. Another participant commented on difficulties she experienced using the Delete gesture.

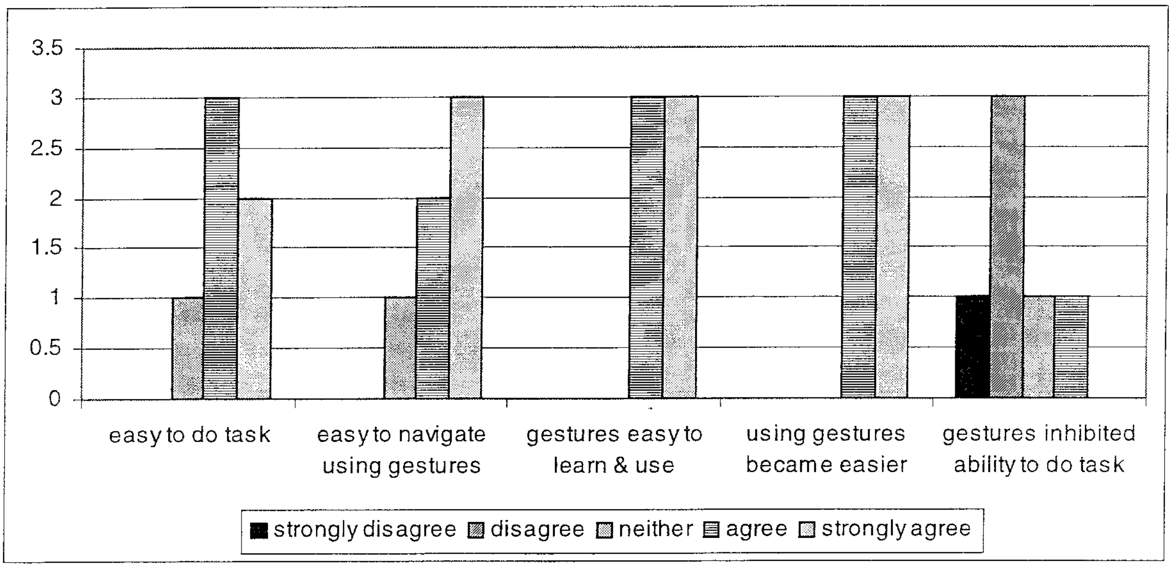


*Figure A4.4 Distribution of responses to questions 4 to 8 of the summary questionnaire.*

Five participants felt that it was easy to navigate around PowerPoint™ using the Next Slide and Last Slide gestures. Three of these participants felt that the gestures were simple to learn and to use. Two participants highlighted difficulties they experienced using the Next Slide or Last Slide gestures. One participant commented on how the Next Slide gesture was confused with a line because he had not drawn the reverse line of the gesture far enough back on itself. Another participant commented on how some of the lines were picked up when she drew the Next Slide and Last Slide gestures before the system was ready.

The sixth participant was neutral about the ease of using the gestures to navigate the PowerPoint™ presentation. She felt that using these gestures to navigate the presentation was not as easy as pushing a button on a remote control, but that it was easier than using a mouse.

All six participants felt that the gestures were easy to learn and use. One participant commented on their simplicity. Another participant commented on their being self-explanatory. One participant felt she would need more practice to get them right all the time. Another participant commented on difficulties she experienced using the Delete gesture and timing the drawing of the Next Slide and Last Slide gestures.

Likewise, all six participants felt that with use the gestures became easier to use. One participant commented on the relatively short learning curve associated with using the gestures and the LIDS technology (about 15 minutes), after which time one is able to focus on the task (rather than on the gestures). Another participant said that he could easily do the gestures after about five minutes, although there were difficulties associated with using the delete gesture (in that you had to ensure that it covered the object completely to work correctly). Another participant commented on the difficulties she had drawing the horizontal lines for the Next Slide and Last Slide gestures.

Four participants felt that using the gestures did not inhibit their ability to present the story. One participant said that it was as easy as using a pen. Another participant felt that although she had to focus on the gestures initially, using the gestures became progressively easier and far more enjoyable in the latter stages. One participant described how colouring in an object by moving the pen back and forth horizontally was confused with the Delete gesture. To accommodate this, he had to colour vertically instead.

One participant was neutral about whether using the gestures inhibited her ability to present her story. She felt that in general using the gestures did not inhibit her ability to present her story, apart from the horizontal lines that appeared at the bottom of the slide when the Next Slide or Last Slide gestures were not correct. She also commented that it felt odd drawing an up-arrow through the picture for the Finish and Save gesture.

One participant felt that using the gestures inhibited his ability to present the story. He gave no explanation for why he felt this way. In relation to his responses to the other questions in the summary questionnaire, his response seems unusual. It is possible that he did not understand the question.

**Features That the Participants Liked and Disliked**

Question 9 in the summary questionnaire asked participants to list three things they liked about the gesture recognition tools. Not all respondents provided three items. The responses to this question are summarised in Table A4.9 and an analysis of the responses is presented below.

| *Likes* | *No. of responses* | *Dislikes* | *No. of responses* |
|---|---|---|---|
| Low complexity | 4 | Delete gesture | 4 |
| Ease of use | 4 | Next Slide/Last Slide gestures | 4 |
| Fast response | 4 | Finish and Save gesture | 2 |
| Specific gestures | 1 | Other | 2 |
| Other | 2 | | |

*Table A4.9 Participant likes and dislikes.*

One the main features of the gesture recognition tools that appealed to participants was the simplicity of the gestures. Four participants liked that the gestures were simple or easy to remember.

The same participants also liked that the gestures were easy to use. Two participants highlighted navigation (the Next Slide and Last Slide gestures) as being easy and intuitive. One participant liked that it was relatively easy to make changes to the slides. Another participant liked the ease with which one is able to create images and to create a story or presentation.

Four participants liked the fast response of the software. One participant liked that it required no input from the keyboard. Another participant liked that you could save the presentation for another time. One participant liked the Delete and Erase All gestures.

Question 10 in the summary questionnaire asked participants to list three things they disliked about the gesture recognition tools. One respondent listed nothing for this question and not all respondents provided three items. An analysis of the responses to this question is presented below and summarised in Table A4.9 above.

The aspect of the gesture recognition tools that participants most frequently disliked related to specific gestures. Four participants disliked aspects of the Delete gesture. Of these, two participants disliked the Delete gesture because difficulties they experienced using it. Another participant disliked that it took longer than the other gestures. One participant disliked that you could not delete an item after it had been saved.

Four participants disliked the Next Slide or Last Slide gestures. One participant disliked both of these gestures. Another two participants disliked that that the line had to be drawn more or less horizontally for the gesture to be recognised. Both participants had a degree of difficulty drawing a horizontal line.

Two participants disliked the Finish and Save gesture. One participant felt that the vertical arrow seems to get in the way of the picture.

Other aspects that participants disliked related to additional effort required in using the LIDS technology and the gesture recognition tools. One participant disliked that it was difficult to create text of uniform size and quality. She related this to the need to remember to apply consistent pressure to the pen when using it. Another participant disliked that using the gestures required forethought as to what he was going to do next.

**Suggested Improvements to the Gesture Recognition Tools**

Question 12 in the summary questionnaire asked participants to identify any features that they would like to see in future versions of the gesture recognition tools. Some participants provided more than one response. Three responses were recorded during observation of the participants in the session. The responses are summarised in Table A4.10 and an analysis is presented below.

One of the most frequently mentioned features for future versions of the technology was modifying the existing gestures. In particular, three participants suggested improvements for the Delete gesture, including making it a three-point gesture instead of a five-point gesture, enclosing items to be deleted in a range (e.g. a box or circle) and then to deleting the range (e.g. by crossing it out), or touching a line on the screen with the LIDS pen for a period of time to make it disappear. Two participants suggested having an optional window (that you could close) in the corner of the screen with buttons for performing the functions supplied by the gestures.

Other features for future versions of the technology were the incorporation of painting tools to enhance the appearance of a PowerPoint™ presentation. These included a wider range of colours, a range of paintbrush sizes and colours, a fill tool for colouring, and an eraser or a brush (of varying width) that acts as an eraser.

Two participants suggested incorporating a text recognition facility. This is already a feature of the LIDS PowerPoint™ presentation tools and was not evaluated in this study.

| *Improvements* | *No. of responses* |
|---|---|
| Modifying existing gestures | 5 |
| Paint tools | 5 |
| Text recognition | 2 |
| New gestures | 3 |
| Other | 2 |

*Table A4.10 Suggested improvements to the gesture recognition tools.*

Participants recommended incorporating other gestures, such as a gesture to move to start of the PowerPoint™ presentation, a copy gesture, so that you can reuse the pictures or characters, and an undo gesture.

One participant suggested incorporating an error message box or a tips message box to help users who experience difficulties using the current suite of gestures. Another participant thought the ability to import images from other areas could enhance a PowerPoint™ presentation.

**Appended List 1: List of Participant Comments About the LIDS Technology**

This appended list presents a summary of various comments made by participants in completing the questionnaires as part of this study. The comments relate to the LIDS technology, and provide a useful source of quotes to illustrate the results presented in this study. Comments are grouped by question.

*Likes*

Low complexity

- simple (P4)
- simple (P1)
- straightforward (P5)
- strokes easy to remember (P3)

Ease of use

- easy to use (P5)
- ease of creating images (P5)
- easy to create a story/presentation (P5)
- relatively easy to change things (P1)
- easy navigation - forward & back (P3)
- intuitive (left to go back, right to go forward) (P4)

Response

- immediate reponse (P1)
- speedy, no significant delay (P3)
- fast to perform (P4)
- fast (P6)

Specific gestures

- delete (P2)
- erase all (P2)

Other

- can save the presentation for next time (P2)
- required no input form key board (P6)

*Dislikes*

Delete gesture

- scrubbing out hard at times (P1)
- delete difficult to use (P5)
- delete takes longer than other gestures (P4)
- could not delete item after it had been saved (P6)

Next Slide/Last Slide gestures

- next slide (P2)
- Last slide (P2)
- need to draw fairly horizontal line for moving forward and back through slide (P1)
- They require a steady hand to draw the straight line (P4)

Finish and Save gesture

- Finish & Save (P2)
- up arrow to save and finish (vertical arrow seems to get in way of the picture) (P1)

Other

- difficult to create text of uniform size and quality (bcs need to remember to apply consistent pressure to pen when using) (P5)
- required a bit of though as to what I was going to do next (P6)

*Improvements*

Modifying existing gestures

- some way of improving ability to erase e.g. touching a line for a period of time to make it disappear (P1)
- delete by enclosing in box (P3)
- 3 point delete instead of 5 (P6)
- a box in corner of the screen with keys to touch for moving back/forward and for save/deletion. Much easier than arrows (P1)

Paint tools

- painting tools e.g. paintbrush with different sizes & colours (P3)
- different brush sizes (P4)
- fill tool for colouring (P6)
- more colours (P4)

Text recognition

- letter recognition (P3)
- hand writing recognition and conversion to text (P4)

New gestures

- copy gesture so that you can use same pictures and characters (P2)
- gesture to go back to start (P4)

Other features

- ability to import images from other areas => more interesting presentation (P5)
- error message box/tips (P3)

*Questions*

Question 1

- Same as using a whiteboard (P2)
- fun drawing with a pen that never runs out (P4)
- creating drawing/text is comfortable & exceedingly easy to do (P5)
- overall, very easy to use (P6)
- fun to draw things on a big screen (p1)
- fairly easy to write/draw/navigate (P3)

Question 2

- Simple ways of moving around and changing things. Although scrubbing out was tricky at times (P1)
- the program response quick; when writing no delay experienced (P3)
- very simple to understand & use (P4)
- gestures are relatively easy to use - significantly easier to use than other presentation packages (P5)

- gestures simple to use, although had to make sure I didn't go too fast for system to keep up (P6)
- easy to understand (P2)

Question 3

- no need to remember complicated commands/strokes (P3)
- required some degree of thought as to motions made with pen (P6)
- focussed more on the story (P2)
- neither technology was interesting bcs it was new. After a while I focussed on task (P4)
- initially focussed on technology; focus shifted as I got used to the gestures, tehn focussed on task (P5)
- both were interesting (P1)

Question 4

- liked being able to go from creen to screen; convenient not to erase what I had written (P2)
- easy to do so because its like using a pen and paper (P3)
- easier than using a whiteboard (P4)
- found it easy to present story using LIDS technology; had some difficulty with the delete gesture, especially with image/text of reasonable size (P5)
- initially difficult until used to gestures (P6)

Question 5

- Most of the time. Some of the lines were picked up when I mis-timed drawing the forward and back arrows.(P1)
- forward/back is just a simple stroke (P3)
- not as easy as pressing a button on a remote buteasier than using a mouse (P4)
- very easy indeed; gestures for navigating thru presentation easy to learn & use (P5)
- simple to use; sometimes next slde gesture was confused with a line bcs I did not draw reverse line far enough back (P6)

Question 6

- Simple. Difficulties of scrubbing out and timing the of drawing back and forward (P1)
- simple to learn but I would need more practice to get them right all the time (P4)
- very easy indeed; gestures for navigating thru presentation easy to learn & use (P5)
- simple strokes (P3)
- self-explanatory (P6)

Question 7

- To some extent - drawing horizontal lines wasn't easy (P1)
- relatively short learning curve in using gestures and LIDS technology (~15 mins) & then you can focus on task (P5)
- could easily do after ~ 5 mins; had to make sure delete gesture covered object completely to work correctly (P6)

Question 8

- They didn't except for the lines that appeared at the bottom of the picture when the horizontal arrows weren't correct for moving between slides. The up arrow through the picture, to finish and save at the end, felt odd (P1)
- Not at all. Initially have to focus on gestures. It does get progressively easier and far more enjoyable to use in the latter stages (P5)
- colouring object was confused with delete gesture; to fix this I coloured vertically instead of horizontally (P6)
- easy as using a pen (P3)

# Appendix 5. The Shadow Technology (Interim Report)

*Prepared by Laurie McLeod (University of Waikato Usability Laboratory)*

## A5.1 Introduction

This report has been prepared by Laurie McLeod of the University of Waikato Usability Laboratory (Usability Laboratory) for Mr Rogers and Dr. Masoodian of the Computer Science Department, University of Waikato. Mr Rogers and Dr. Masoodian are the developers of the shadow technology used in conjunction with the Large Interactive Display Screen (LIDS).

This report is provisional only, owing to time constraints and the fact that not all of the data collected has been interpreted and analysed. It presents preliminary results of aspects of a usability study conducted at the Usability Laboratory into the use of shadow technology and the LIDS between 29 January and 12 February, 2002.

The main purpose of the study is to inform the developers of the technology of any issues associated with the use of the shadow technology and LIDS that may impact on the effectiveness of the intended users' ability to interact and communicate with other users working on the same task but who will not be in the same room.

## A5.2 Method

Twenty-four participants were involved in the study. This included 9 females and 14 males. Participants were students of the University of Waikato who recruited by advertising posters displayed on various notice boards around Campus. Two participants were involved in each session. Each session lasted two hours. There were three male pairs, one female pair and eight mixed female-male pairs. These are shown in Table A5.1 (the gender of each participant is shown in brackets).

Due to a participant failing to arrive at the scheduled time, session eight was conducted at two separate times. In both cases, a worker from the Usability Laboratory played the part of the second person in the study. They played a minimal role in the task and avoided taking the lead in the tasks. No observations were made for this person.

The study was conducted in two rooms (nominally referred to as room A and room B). Each room had a LIDS screen and a pen. The two rooms had audio contact. Both rooms had speakers. The user in room A used a headset, while the user in Room B held a microphone. Room A had two cameras placed for observation of users at the LIDS screen. One camera was positioned to view the screen of the LIDS from directly in front of the LIDS, giving a view of the user and the screen from directly behind the user. The other camera was positioned at an angle in front and to the side of the LIDS, giving a view of the user and the screen from behind the right shoulder of the user (facing the screen). Room A had a scan converter connected to the slide projector to collect the output from the computer to enable recording of what was being presented to the screen. Room B had one camera placed for observation of the user at the LIDS screen. The camera was positioned at an angle behind the user to give a view of the user and the LIDS from behind the right shoulder of the user (facing the screen).

A quad splitter was used to combine the four images which were then arranged to show the LIDS screen in the top left hand corner, the camera image directly behind the user in room A in the top right hand corner, the other camera image of the user in room A in the bottom left hand corner and the camera image of the user in room B in the bottom right hand corner. Room B had another camera that was part of the shadow technology. It was situated behind the user and facing the LIDS (about 1.5 m from the LIDS screen). Room A was used for the three different technology scenarios, while room B was used for the two of the technology scenarios (see below).

| *Session Number* | *Participant Number* | |
|---|---|---|
| 1 | P1 (M) | P2 (M) |
| 2 | P3 (F) | P4 (M) |
| 3 | P5 (F) | P6 (M) |
| 4 | P7 (F) | P8 (M) |
| 5 | P9 (F) | P10 (M) |
| 6 | P11 (F) | P12 (M) |
| 7 | P13 (F) | P14 (M) |
| 8 | P15 (M) | P16 (M) |
| 9 | P17 (F) | P18 (M) |
| 10 | P19 (F) | P20 (F) |
| 11 | P21 (F) | P22 (M) |
| 12 | P23 (M) | P24 (M) |

*Table A5.1 Participant pairings for the 12 sessions of the study.*

Each session consisted of three tasks which were always performed in the same order. The tasks were aimed at an age level of around 10 years. The first task involved completing six short crosswords in which the participants had to enter a vowel (from a list of six options to complete all six crosswords) into the centre of four consonants arranged in a 'T' shape with a space at the centre to form two words when read left to right and top to bottom. The second task involved a word search of different dog breeds, comprising of a block of characters (x letters by x letters) at the top with a list of words to be found below (three columns each of x words). The third task consisted of 10 games of noughts and crosses ('0's and 'X's or 'tic-tac-toe').

The three tasks were performed under three scenarios each involving the use of a different technology. One scenario involved the two participants working together on the designated task in the same room on the same LIDS screen and sharing a pen (room A). We refer to this scenario as Non-Distributed (ND). Another scenario involved the two participants working together on the designated task in two separate rooms (rooms A and B), each with a LIDS and a pen. They had audio contact. We refer to this scenario as Distributed with No Shadow (DNS). The other scenario involved the two participants working together on the designated task in two separate rooms (rooms A and B), each with a LIDS and a pen. They had audio contact. In addition, the user in room A was able to see the shadow of the user in room B. We refer to this scenario as being Distributed with Shadow (DS).

The order in which the different technology scenarios were performed in each session varied according to the experimental design shown in Table A5.2. The duration of each task varied, with the first task being the fastest to be completed. Participants were generally given up to fifteen minutes to perform a task. If they completed the task before the given time, the task was deemed completed. With the shadow technology, the task was interrupted half way (either at 7.5 minutes or when the half of the task had been completed) and the participants changed rooms. This enabled each participant to experience the shadow technology.

| *Session Number* | *Technology Scenario* | | |
|---|---|---|---|
| | *Task 1 (crossword)* | *Task 2 (word search)* | *Task 3 (0s and Xs)* |
| 1, 8 | ND | DNS | DS |
| 2, 7 | ND | DS | DNS |
| 3, 9 | DS | ND | DNS |
| 4, 10 | DS | DNS | ND |
| 5, 11 | DNS | ND | DS |
| 6, 12 | DNS | DS | ND |

*Table A5.2 Experimental design for the 12 sessions (by task and technology scenario).*

Sessions began with an introduction to the study, a brief training session using LIDS, followed by an initial questionnaire that ascertained participants' initial attitudes about the LIDS technology. The main part of the session consisted of the three tasks, each utilising a different technology scenario, and each concluding with a summary questionnaire. When all three tasks and their questionnaires had been completed, a final questionnaire was administered comparing the participants' experiences with the three technologies. This was accompanied by a debriefing.

Observations of each session involved note-taking during the sessions, observation of the video tape recordings of each session, and analysis of the five questionnaires completed by each participant.

The technology failed in a number of cases, as reported in the first appended list.

## A5.3 Results

The following sections present the results of the part of the study concerning the shadow technology. These include participants' perceptions of the shadow technology, their experience of using the technology, features about the technology that they liked and disliked, and suggested improvements to the shadow technology. Various comments that participants made about the shadow technology are presented in second appended list.

### The Participants' Perceptions of the Shadow Technology

Question 13 in the summary questionnaire for the distributed with shadow technology scenario asked participants to use a 7-point scale to record their feelings about 8 aspects of the shadow technology. Each scale consisted of a pair of extremes: complex – simple, low tech – high tech, unreliable – reliable, complex to use – easy to use, unfriendly – friendly, unattractive – attractive, low quality – high quality, dislike – like. In our data analysis we have assigned a value of 0 to the midpoint of each scale, negative values moving towards the left-hand extreme of each pair (-1, -2, -3), and positive values moving towards the right-hand extreme of each pair (1, 2, 3). Two participants did not complete this question. The responses of the other 22 participants were used for this analysis.

The mean values of participants' perceptions of the shadow technology for each aspect evaluated are shown in Figure A5.1. All aspects of the shadow technology had a mean value to the right of the midpoint for each scale, reflecting a generally positive attitude to the shadow technology. The highest average value was obtained for the ease of use (at 2.2), which is statistically significantly different (to 95%) from the two lowest ranking average values obtained for quality (0.6) and attractiveness (0.4) of the shadow technology. The other mean values are not significantly different from each other. The distribution of responses for each of the eight scales used in question 13 is illustrated below in Figure A5.2.

```
                                         Individual 95% CIs For Mean
                                         Based on Pooled StDev
                                Mean     ---+---------+---------+---------+---
Complex - simple to use         2.2                        (-----*------)
Complex - simple                1.7                     (-----*------)
Unfriendly - friendly           1.6                    (-----*------)
Low tech - high tech            1.4                  (-----*------)
Dislike - like                  1.4                  (-----*------)
Unreliable - reliable           1.4                 (------*-----)
Low quality - high quality      0.6           (-----*------)
Unattractive - attractive       0.4       (------*-----)
                                         ---+---------+---------+---------+---
                                           0.0       1.0       2.0       3.0
```

*Figure A5.1 Mean values of participants' perceptions of the shadow technology.*

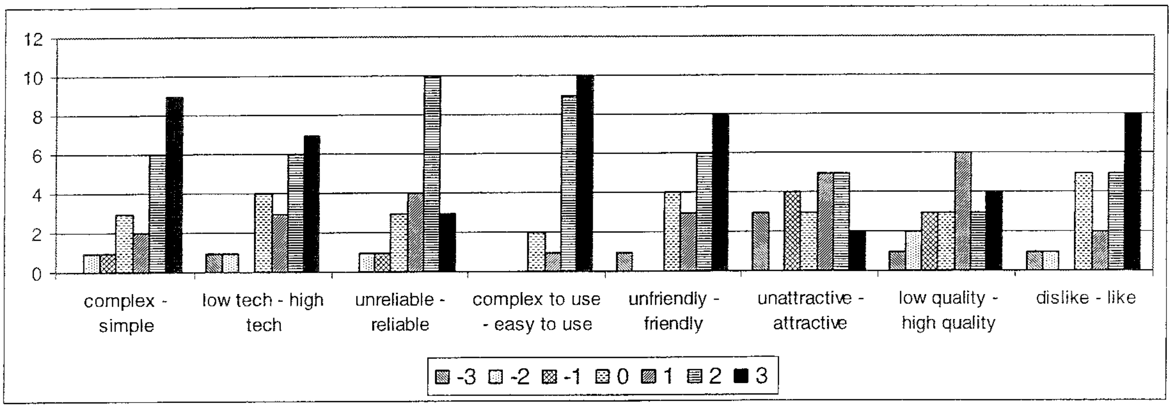


*Figure A5.2 Participants' perceptions of the shadow technology.*

To gauge the overall perception of the shadow technology held by individual participants, we calculated an overall average rating across all eight aspects for each participant. For 15 participants, the average value across all of the categories was at least 1.0. Of the remaining participants, six participants had an average value of 0.5 or under. One participant had a negative average value. This participant consistently expressed negative feelings towards the shadow technology except about the complexity of use, which he felt was relatively simple to use. The latter seven participants were either neutral or disliked the shadow technology when they evaluated that particular aspect. In fact, the group of overall average values showed a strong correlation (correlation coefficient of 0.80) with the individual values for the "like – dislike" scale.

**The Participants' Experience of the Shadow Technology**

The summary questionnaire for each of the technology scenarios asked a number of questions that were identical across the three summary questionnaires. For this preliminary report, we have identified four questions that are relevant to the evaluation of the shadow technology. Each of these questions asked participants to rate their agreement with a particular statement on a five-point scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree).

The four questions (questions four to seven in the questionnaires) were:

"4. I found my group worked well together."

"5. I found that I was aware of the other user at all times."

"6. I found that I was aware where the other user was standing at all times."

"7. I found that I was confident that the other user was aware of what I was doing at al times."

In our data analysis we have assigned a value of 1 to the response "strongly disagree", 2 to "disagree", 3 to "neither agree or disagree", 4 to "agree" and 5 to "strongly agree". For each question, we compared the responses for the shadow technology (Distributed with Shadow questionnaire) to the responses of each of the other two scenarios (Distributed with No Shadow questionnaire and Non-Distributed questionnaire). The mean results for each question are presented by scenario in Table A5.1.

Within each question, the responses for the Distributed with Shadow scenario were statistically compared with the responses for the other two scenarios using the t-test (paired two sample for means). The null hypothesis was either that ΦS (the mean for the Distributed with Shadow scenario) was the same as ΦN (the mean for the Non-Distributed scenario) or that ΦS was the same as ΦD (the mean for the Distributed with No Shadow scenario). The null hypothesis was rejected in three cases. That is, ΦS was significantly different from ΦD for questions five and six, and ΦS was significantly different from ΦN for question seven.

Questions five to seven related to awareness of a participant – awareness of the other participant (question five), awareness of the other participants' position (question six) and confidence that the other participant was aware of the participants' actions (question seven). In each of these cases, we would expect awareness to be most positively affirmed in the non-distributed scenario (participants were in the same room) and awareness to be more positively affirmed with the shadow technology than without it, in the distributed scenarios. This is partially confirmed by the results presented in Table A5.3. Awareness of the other participant is not significantly different between the non-distributed scenario and when the shadow technology is used. However, awareness of the other participant is significantly different (greater) with the shadow technology when compared to the distributed scenario with no shadow. Confidence of the other participant's awareness of the participant was not significantly different between the two distributed scenarios, but it was significantly different (lower) using the shadow technology compared with the non-distributed scenario.

Question four examined whether participants thought that their group worked well together under the three different scenarios. One might expect that in a distributed situation using the shadow technology would increase the extent that the group worked well together. The results do not support this expectation. There was no statistically significant difference between the means of the participants' responses between any of the three scenarios.

The summary questionnaire for the shadow technology scenario asked three further questions about participants' experiences with the shadow technology. Each of these questions asked participants to rate their agreement with a particular statement on a 5-point scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree).

The three questions were:

"8. I enjoyed working with the shadow technology."

"9. I found that I quickly became used to the shadow technology."

"10. I found the shadow technology to be valuable when working with another user in a different location."

| *Question* | *Non-Distributed (ΦN)* | *Distributed with No Shadow (ΦD)* | *Distributed with Shadow ()ΦS* |
|---|---|---|---|
| 4 | 4.2 | 4.1 | 3.9 |
| 5 | 4.3 | 3.8 | 4.3* |
| 6 | 4.3 | 1.9 | 4.0** |
| 7 | 4.6 | 3.4 | 3.6# |

* ΦS was significantly different from ΦD at p=0.05

** ΦS was significantly different from ΦD at p=0.01

\# ΦS was significantly different from ΦN at p=0.01

*Table A5.3 Mean responses for questions 4 to 7 for the 3 technology scenarios.*

The responses are summarised in Figure A5.3. Two participants did not complete these questions, so only the responses of the other 22 participants were used. Overall, most participants enjoyed using the shadow technology and found it quick to learn. The responses were more spread for question 10. Just over half (12) of the participants agreed that the shadow technology was valuable when working with another user in a different location. Four disagreed with this statement, and six were ambivalent.

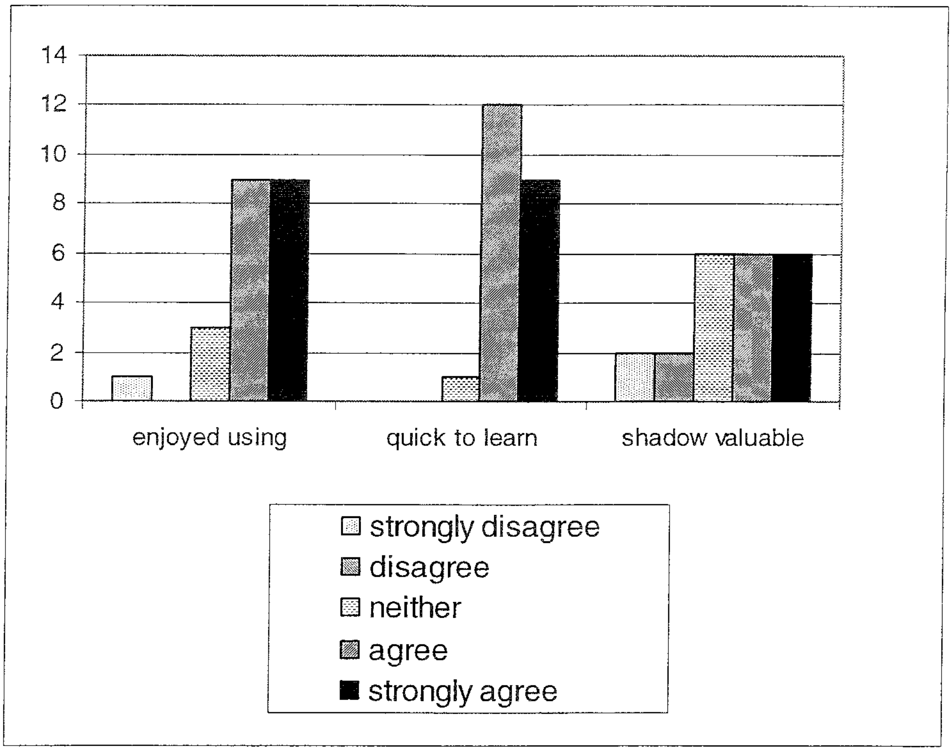


*Figure A5.3 Distribution of responses to questions 8 to 10 from the Distributed with Shadow questionnaire.*

At the end of the session, participants completed a questionnaire comparing their experiences across the three technology scenarios. Each question asked participants to choose which scenario best described their experiences in relation to a particular aspect of using the LIDS technology. The three scenarios were described as: "when in the same room as the other user", "when we were in separate rooms but did not use the shadow technology", and "when we were in separate rooms and used the shadow technology".

The questions were:

"1. I found collaboration easiest:"

"2. I found that I focused more on the technology:"

"3. In general, I most enjoyed myself:"

"4. I found my group worked best together:"

"5. I found that I was most aware of the other user:"

"6. I found that I was most aware of where the other user was standing:"

"7. I found that I was most confident that the other user was aware of what I was doing:"

"8. I found that I was best able to follow what was going on:".

The distribution of responses for the eight comparison questions is shown below in Figure A5.4. Note that the number in brackets shown below the question number is the number of responses to that question. Not all respondents answered every question.

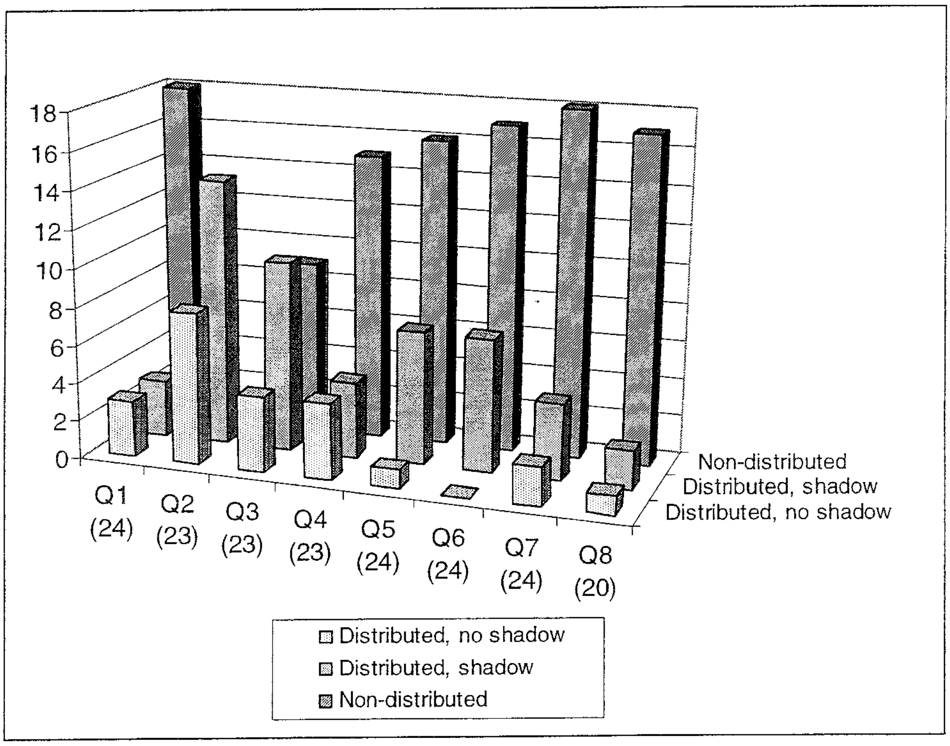


*Figure A5. 4 Distribution of responses to questions in the comparison questionnaire.*

As the eight questions asked participants to compare their experiences across all three technology scenarios, it is perhaps not surprising that generally most respondents found collaboration, group functioning, awareness of each other and being able to follow what was going on best when in the same room as the other user (questions one and four to eight). What can be concluded from these results is that more participants focused on the technology when using the shadow technology (question two). Also, participants tended to be evenly split in their enjoyment of the experience between being in the same room and being in separate rooms using the shadow technology (question three).

**Features that Participants Liked and Disliked**

Question 11 in the summary questionnaire for the shadow technology scenario asked participants to list three things they liked about the shadow technology. Not all respondents provided three items. The responses to this question are summarised in Table A5.4 and an analysis of the responses is presented below.

| *Likes* | *No. of responses* | *Dislikes* | *No. of responses* |
|---|---|---|---|
| Awareness of position | 12 | Shadow quality | 17 |
| Awareness of actions | 9 | Extraneous shadow | 7 |
| Shadow helpful | 9 | Shadow not helpful | 4 |
| Shadow not distracting | 5 | Shadow distracting | 5 |
| Fun and novel | 4 | Technical problems | 6 |
| More personal | 4 | | |
| Performance of shadow | 4 | | |

*Table A5.4 Participant likes and dislikes.*

The most frequently mentioned items related to a participant's awareness of the other participant. Twelve participants liked the way the shadow technology made them aware of the other participant's position. They expressed this as being able to see the other person, knowing the other person was there and knowing where the other person was located. Nine participants emphasised how the shadow technology made them aware of the other person's actions. They expressed this as being able to see the other person's actions and being able to anticipate their actions.

Nine participants identified the shadow technology as being helpful. By this they meant that it facilitated interaction, coordination of task work, or teamwork. Two of these participants suggested that the shadow assisted their communication by reducing the need for oral communication. Five participants mentioned that the shadow did not hinder their work or obscure what they were doing.

Some of the participants appeared to enjoy the shadow technology, commenting on its novelty or that it was fun to use. Other participants liked the way the shadow technology made the experience more personal or comfortable.

Participants also commented on the aspects of the performance of the shadow technology. For example, they liked the way the shadow was combined with the workspace on the screen, or the real-time nature of the interaction that the shadow facilitated.

Question 12 in the summary questionnaire for the shadow technology scenario asked participants to list three things they disliked about the shadow technology. Not all respondents provided three items. An analysis of the responses to this question is presented below and summarised in Table A5.4 above.

The aspect of the shadow technology that participants most frequently disliked related to the quality of the shadow. There were 17 comments, including the large size of the shadow, the low resolution or "grainy" image, the lack of smooth edges and that the shadow did not provide enough detail about the other participant's gestures.

Seven participants disliked the way in which the shadow technology cast extraneous shadows other than that of the participant. They noted that when other things were cast on the screen it became difficult to read or was confusing.

Four participants said they did not find the shadow helpful or that they could do without it. One of these participants said he did not understand the purpose of the shadow. Five participants found the shadow was (or could be) distracting.

Six participants identified technical problems with the shadow technology. Three noted that it seemed to slow things down and two noted that it seemed to make hearing more difficult. The sixth participants disliked that under the present arrangement only one participant could have the shadow.

**Suggested Improvements to the Shadow Technology**

Question 14 in the summary questionnaire for the shadow technology scenario asked participants to identify any features that they would like to see in future versions of the shadow technology. Not all participants provided an answer to this question and some participants provided more than one response. Four responses were recorded during observation of the participants in the session. The responses are summarised in Table A5.5 and an analysis is presented below.

| *Improvements* | *No. of responses* |
|---|---|
| Include video image | 9 |
| Improve shadow resolution | 8 |
| Remove extraneous shadow | 2 |
| Alternative shadow formats | 6 |
| Make shadow optional | 2 |
| Technical improvements | 3 |
| Alternative evaluation | 6 |
| Other comments | 3 |

*Table A5.5 Suggested improvements to the shadow technology*

The most frequently mentioned feature for future versions of the technology was the incorporation of a video image of the other participant, usually in addition to the shadow and often of just the participant's face.

Consistent with the results reported above on features that participants disliked, eight participants suggested improving the shadow resolution to give crisper shadow definition, smoother lines and a more flowing shadow movement. Two participants recommended removing the extraneous shadows noted as a problem by some participants.

Six participants suggested using alternative shadow formats to that currently used. These included the use of different coloured shadows, different shades to create a three-dimensional effect, just an outline, or using a transparent image instead of a shadow. Two participants suggested making use of the shadow optional.

Three participants suggested technical improvements, namely a faster network connection, better quality sound and an adjustable screen height.

Six participants used question 14 to suggest alternative ways to evaluate the shadow technology. Two of these noted that some of the tasks used in the study did not fully evaluate the shadow technology. One suggested providing participants with the tasks in advance. Three questioned how the technology would perform in more than two locations or with more than one person in each room.

A participant commented that the shadow technology was a good solution to the bandwidth problem. Another noted that teams using the shadow technology over distributed locations would perform better if they knew each other (this participant encountered language problems with the other participant in her session). One participant suggested that users might suffer eye problems with prolonged use of the shadow technology.

**Appended List 1: List of Technology Failures**

The following problems (see Table A5.) were noted during observation of the sessions. This is not necessarily an exhaustive list due to the limitations of human observation of two rooms. The extent and nature of the problems will need to be cross-checked against the video evidence for each session. Some of these problems were also noted by participants in their summary questionnaires. After session three, a modified version of the LIDS software was used, to overcome some of the problems of gesture mimicking.

**Appended List 2: List of Participant Comments about the Shadow Technology**

This appended list presents a summary of various comments made by participants in completing the questionnaires as part of this study. The comments relate to the shadow technology, and provide a useful source of quotes to illustrate the results presented in this study.

Each comment has been summarised and given a code indicating the source of the comment (the code is enclosed in brackets). The code uses the format (xyz) where x is the participant number (1-24), y is the question source ('S' for the Distributed with Shadow questionnaire, 'D' for the Distributed with No Shadow questionnaire, 'N' for the Non-Distributed questionnaire, and 'C' for the comparison questionnaire), and z is the question number. The comments are group thematically.

*Awareness of position*

- shadow gave relative position of other person(6S6)
- aware of other's position but not details(8S6)
- useful to know someone is at other location(8S10)
- useful to see where other person was(11S1)
- shadow showed where partner was standing(19S7,19C2)
- shadow indicated whether other person was present and where they were standing(20S6)
- increased awareness(5S5)
- most aware when following other's position(3C5)
- my focus was drawn to her because of the shadow(15C5)
- helpful to know that other person was aware of my position and actions(11S7)
- without shadow could not see partner's location(18D6)

| *Session No.* | *Task* | *Technology scenario* | *Problem description* |
|---|---|---|---|
| 1 | Word search | DNS | Towards the end, error message: "memory could not be read". Restarted. At end, problem in Room B and Room A lost pen response. |
| 2 | Word search | DS* | Problems with drawings mimicking gestures. |
| 3 | Crossword | DS* | Assertion failure notification at beginning. Restarted. Later system crashed or not responding. Restarted.<br>Problems with drawings mimicking gestures. |
| 4 | Word search | DNS | System in Room B appeared to crash. Restarted. |
| 5 | 0 and X | DS | Problem with system in Room B(?). Restarted. |
| 6 | Word search | DS* | Room A crashed (could not read memory?). Restarted. Later, audio loop. Swapped rooms. Restarted. Later, Room B had glitch (PowerPoint contacting MS). Restarted. |
| 8b# | Word search<br><br>0 and X | DNS*<br><br>DS | Trouble with pen in Room B.# Later, system crashed; error message: could not read memory. Restarted. At end, trouble with pen response.#<br><br>At end, mimeo device in Room B died.# |
| 9 | Crossword | DS* | At end, audio loop; "line 246" error on memory read, scribbles and shadow unaffected |
| 12 | Word search | DS | Audio loop after about 7 minutes. Swapped rooms. Restarted. After a while, system slow and audio loop. |

* Participants noted problems for these scenarios in their summary questionnaires

\# Session 8 was done in 2 parts. Problems with pen were only experienced by Usability Laboratory staff member in Room B who partnered the participant in this session.

*Table A5.6 List of technology failures.*

*Awareness of actions*

- can see shadow of other person and what they are doing clearly(2S5,2C1)
- could see partner's shadow and what partner placed on board(16S5)
- could see what doing or about to do(22S5)
- could predict other person's moves from their shadow(21S5,21S8)
- without shadow other person could only see actions after they were done(5D7)
- without shadow did not know where other person was going to write(11D11)
- distributed but without shadow, sometimes both started on same task at same time(19D5)
- distributed but without shadow, sometimes both started on same task at same time(20D2)
- they could see what I was doing(22S7)

*Assisted communication*

- shadow meant less verbal communication needed(3S8,3D7)
- without shadow extra effort/communication required(4C5)
- easy to communicate with shadow(22S4)
- without shadow reliant on speaking or writing(10D5)

*Audio more important*

- relied on voice communication(7S10)
- used audio as well as shadow(8S5)
- shadow was enjoyable but voice commands more valuable in distributed setup(15S10)
- awareness through voice(17D5)
- shadow complemented voice(20S5)
- communication easy with audio connection(19S4)
- still aware of other person through audio(8D5)

*More personal*

- collaboration more personal(4S8)
- more personal(5S10)
- felt less natural when could not see other person(5C2)
- having the shadow gave a more personal feel to the interaction(20S10)
- shadow (knowing where they were) made me feel more comfortable(22S2,22S10)
- process felt more remote without shadow(23C2)

*Fun*

- like shadow puppets(5S8)
- cool and fun to play with(8S8)
- like in cyberspace(10C3)
- cool and novel(13S8)
- exciting/interesting to see other user(10C4)

*Easy to use*

- easy to pick up(8S9)
- very easy to use, enjoyable, very useful for off-location meetings(11C9)
- easy, simple, quick (to learn)(15S9)
- easy to learn(17S9)
- simple to use(19C9)
- does not require much training(19C9)

*Distracting*

- sometimes shadow might distract(10C9)
- shadow sometimes distracting(4S5,4C2)
- shadow sometimes distracting(12C1)

- quite visually distracting(13S8)
- shadow can be annoying(24S9)
- shadow from letters was distracting(23S5)

*Not distracting*

- unobtrusive(59)
- easy to adapt to as does not impose on the screen(22S9)
- shadow did not distract from letters written(6S9)
- ignored shadow after several minutes(4S9)
- after a while shadow was irrelevant (ignored it)(14S6)

*Focus*

- focused on shadow(3C2)
- increased focus on technology with shadow(8C2)
- concentrated on other person as well as task when had shadow(19C2)

*Obscuring*

- cannot see partner's actions if writing in front of themselves(18S8)
- shadow obscured a little(6S2)

*Helpful*

- shadow makes it a valuable tool when working on one task in different locations(19C9)
- much better than no shadow(22S8)
- shadow technology added that extra dimension(22C3)
- partner displayed in front of me rather than peripherally and could see what partner was doing(15C6)
- like they are in the same location(17S10)

*Not helpful*

- just having a shadow is not that helpful(12S10,12S15)
- added no value in helping perform task(0&X)(16S10)
- just as easy to use without shadow(18S10)

*Shadow quality*

- blocky but recognisable(5S6)
- large => positioning not exact(4S6)
- shadow actions not always clear(6S7)
- parts of other person did not cast a shadow(13S14)
- shadow slow moving and should have smoother edge(18S1)
- little room for gestures(18S9)
- shadow is not like having a proper image(14S8)

*Technical problems*

- computer too slow with shadow(24S3)
- somewhat disconcerting talking to a shadow with a rough voice(20S7)

# Appendix 6. The Physical Technology: Ergonomic Issues (Interim Report)

*Prepared by Laurie McLeod (University of Waikato Usability Laboratory)*

## A6.1 Introduction

This report looks at ergonomic aspects of the LIDS pen and screen. It draws from two studies: the interactive gesture recognition tools study and the shadow technology study, conducted at the Usability Laboratory during January and February 2002. Full details of these studies have been reported previously. This report focuses on the use of the LIDS pen and the LIDS screen within those studies.

## A6.2 Use of the LIDS Pen

The following sections present the results of the part of the LIDS studies concerning the use of the LIDS pen. These include the participants' perceptions of the LIDS pen, their experience of using the LIDS pen, features about the pen that they liked and disliked, and suggested improvements to LIDS. Any comments made by participants in the summary questionnaires are presented in Appendix 1.

**Participants' Perceptions of the LIDS Pen**

*The Interactive Gesture Recognition Tools Study*

Question 22 in the summary questionnaire for the interactive gesture recognition tools study asked participants to use a seven-point scale to record their feelings about 8 aspects of the gesture recognition tools. Each scale consisted of a pair of extremes: complex – simple, low tech – high tech, unreliable – reliable, complex to use – easy to use, unfriendly – friendly, unattractive – attractive, low quality – high quality, dislike – like. In our data analysis we have assigned a value of 0 to the midpoint of each scale, negative values moving towards the left-hand extreme of each pair (-1, -2, -3), and positive values moving towards the right-hand extreme of each pair (1, 2, 3). All participants completed this question.

The distribution of responses for each of the eight scales used in question 22 is illustrated below in Figure A6.1. Participants' perceptions of the LIDS pen were favourable. Most participants felt that the LIDS pen was not complex or unfriendly, and that it was reliable, attractive, of high quality and simple to use. All but one participant (who was ambivalent) liked the LIDS pen.

*The Shadow Technology Study*

The summary questionnaires of the shadow technology study did not ask participants about their perceptions of the LIDS pen.

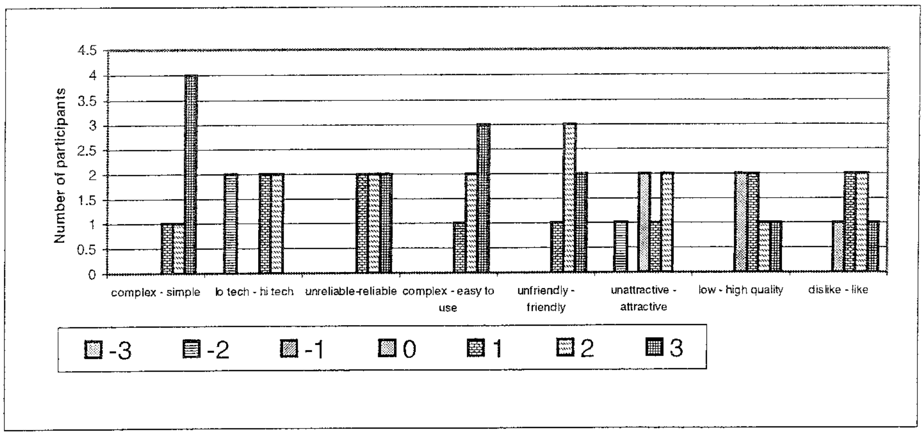


*Figure A6. 1 Participants' perceptions of the LIDS pen (interactive gesture recognition tools study).*

**Participants' Experience of the LIDS Pen**

*The Interactive Gesture Recognition Tools Study*

The summary questionnaire of the interactive gesture recognition tools study asked participants three questions about their experiences using the LIDS pen. Each of these questions asked participants to rate their agreement with a particular statement on a five-point scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree). The questions were:

"17. I found the LIDS pen easy to learn and use."

"18. I found that with use the LIDS pen became easier to use."

"19. I found that the LIDS pen inhibited my ability to present my story."

The distribution of responses for these questions is shown in Figure A6.2.

All six participants found the LIDS pen easy to learn and to use. One participant likened using the pen to using a mouse. Another participant commented that drawing with the pen was easy but writing was more difficult. Another participant said that he did not push hard enough at times.

Five participants found that with use the pen became easier to use, while the other participant said she did not notice any change. Two participants related this to learning the correct amount of pressure to apply when using the pen. During one session, the participant commented on this aspect:

> *"I think the most difficult aspects were deleting and remembering to apply consistent pressure when actually writing text ... The picture drawing was actually really fun ... It doesn't flow as easily as drawing images." (P5)*

Four of the participants disagreed that the use of the pen inhibited their ability to perform the task of telling a story, although one of them stated that he had difficulty colouring in. The other two participants were neutral about whether the pen inhibited their ability to tell the story. One participant related this to her poor drawing ability and the other related it to difficulties she experienced in creating text.

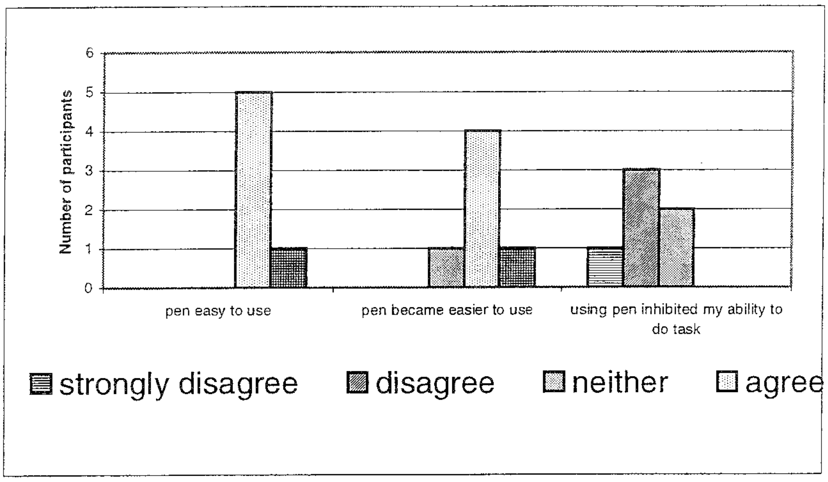


*Figure A6. 2 Distribution of responses to questions 17 to 19 of the summary questionnaire of the interactive gesture recognition tools study.*

## *The Shadow Technology Study*

The summary questionnaires for each of the three tasks in the shadow technology study asked participants two questions about their experiences using the LIDS pen. Each question asked participants to rate their agreement with a particular statement on a five-point scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree). The numbering of the questions varied between the summary questionnaires for the tasks. The questions were:

> "I found the LIDS pen comfortable to use."
>
> "I found it easy to write on the LIDS screen with the pen."

Across the three tasks, most of the participants were reasonably consistent in their rating of whether they found the LIDS pen comfortable to use. Nine participants gave the same rating for each task; twelve participants varied by only one rating value on the five-point across the three tasks. Three participants, however, showed more varied responses.

One participant progressively improved her rating of the comfortableness of using the pen from the first task to the last task. Her ratings (for task one, two and three respectively) were: disagree, neither agree nor disagree, and agree. She related the improvement to more experience in using the pen.

In contrast, two other participants progressively downgraded their rating of the comfortableness of using the pen from the first task to the last task. The ratings of one participant (for task one, two and three respectively) were: strongly agree, neither agree nor disagree, disagree. The ratings of the other participant (for task one, two and three respectively) were: agree, disagree, disagree. Both participants commented on the pen being more uncomfortable to use with prolonged use. One participant related this to the pen size, noting that the LIDS pen needed to be smaller for longer-term use.

The distribution of responses for this question is shown in Figure A6.3. Where the rating of a participant varied only by one point on the five-point scale, the most common rating was used. Two participants gave three different ratings across the tasks and their responses were excluded from the analysis.

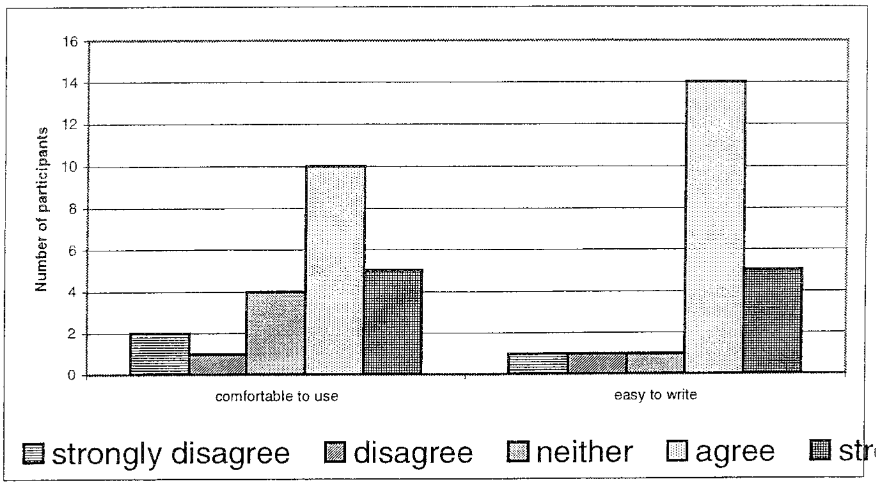


*Figure A6. 3 Distribution of responses to questions about the LIDS pens in the shadow technology study.*

Fifteen participants agreed that the LIDS pen was comfortable to use. Five participants felt that the pen was comfortable, easy to grip or easy to use. Three other participants likened it to using a normal pen (only it was bigger), and two participants likened it to a whiteboard pen. Two participants said they would have preferred a smaller pen.

Of the remaining participants, three disagreed that the pen was comfortable to us, and four participants neither agreed nor disagreed that the pen was comfortable to use. Four participants commented on the size of the pen.

Across the three tasks, most of the participants were reasonably consistent in their rating of whether they found it easy to write on the LIDS screen with the pen. Seven participants gave the same rating for each task; twelve participants varied by only one rating value across the three tasks. Five participants, however, showed varied responses (see Table 2.1). Three participants improved their rating of the ease of writing with the pen between the first and last task. One participant felt that it became easier with practice. In contrast, two participants downgraded their rating of the ease of writing with the pen for one of the tasks. Of the task in which these participants had difficulty writing with the pen, one felt that the pen was too bulky, and the other commented that the pen was difficult to grip which made it hard to draw.

| *Participant #* | *Task 1* | *Task 2* | *Task 3* |
|---|---|---|---|
| P4 | disagree | agree | strongly agree |
| P7 | disagree | agree | agree |
| P23 | disagree | neither | agree |
| P11 | agree | disagree | agree |
| P16 | agree | agree | disagree |

*Table A6. 1 Varied responses of participants to the ease of writing with the pen across the three tasks.*

Nineteen participants agreed that it was easy to write on the LIDS screen with the LIDS pen. Eight participants commented on the ease of writing. Their comments included that writing with the pen was smooth, it did not require too much pressure, or it was like using a whiteboard pen or a pen. Other participants commented on some of the requirements of writing with the LIDS pen, including the need to maintain contact between the pen and the screen or to apply consistent pressure when writing. Three participants commented on the poor quality of the writing or drawing either because of difficulties they experienced in gripping the pen or when moving the pen too quickly. One participant drew attention to the offset between the line drawn on the screen and the location of the pen.

Of the remaining participants, two disagreed that the pen was easy to write with, and one participant neither agreed nor disagreed with this. The participants commented on the need to hold the pen horizontally and in contact with the screen.

Five of the participants in the shadow technology study had also previously participated in the interactive gesture recognition study. The ratings for this question conform with the ratings they gave for question 17 of the summary questionnaire of the gestures study about the pen being easy to learn and use.

**Features of the LIDS Pen that Participants Liked and Disliked**

Question 20 of the summary questionnaire of the interactive gesture recognition tools study asked participants to list three things they liked about the LIDS pen. Not all respondents provided three items.

This question was not asked in the summary questionnaires for the shadow technology study. However, in answering the questions about their experiences using the LIDS pen (see the last section), participants provided a number of comments from which were gleaned features of the LIDS pen that the participants liked or thought favourably about. These have been amalgamated with the features listed by participants in the interactive gesture recognition tools study. Any features presented by the five participants who participated in both studies were only included once.

The features of the LIDS pen that participants liked or commented favourably about are summarised in Table A6.2 (see the first appended list for a full list of these). An analysis of the responses is presented below.

| *Likes* | *No. of responses* | *Dislikes* | *No of responses* |
|---|---|---|---|
| Ease of use | 12 | Difficulties of use | 26 |
| Pen size | 5 | Pen size | 12 |
| Pen shape | 6 | Pen shape | 9 |
| Positive comparisons | 8 | Negative comparisons | 4 |
| Using the pen | 2 | Pen noise | 4 |
| Other | 8 | Other | 4 |

*Table A6. 2 Features of the LIDS pen that the participants liked or disliked.*

One of the main features that participants liked about the LIDS pen was the ease of use. A number of participants commented generally on the ease of use. Others felt that the pen was easy to draw or write with. One participant liked that it was generally responsive and another liked that it worked at most angles.

Participants also commented favourably on the size and shape of the LIDS pen. Five participants found the size of the pen to be appropriate. They felt that it was not too big or heavy or that it was appropriate size for the task. Six participants thought that the pen was comfortable, easy to grip or that it fitted their hand.

Four participants compared using the LIDS pen to using a whiteboard marker, while three others likened it to using a conventional pen. One participant said that it was more like a stick than a pen.

Two participants commented favourably that it did not require too much pressure when using the LIDS pen.

Other features that participants liked about the LIDS pen were that it was reliable, responsive or smooth. One participant liked the colour of the pen. Two participants liked that the pen could write forever and one participant liked that it did not smudge. Another participant liked the range of colours available when using the pen.

Question 21 of the summary questionnaire of the interactive gesture recognition tools study asked participants to list three things they disliked about the LIDS pen. Not all respondents provided three items.

This question was not asked in the summary questionnaires for the shadow technology study. However, in answering the questions about their experiences using the LIDS pen (see section the last section), participants provided a number of comments from which were gleaned features of the LIDS pen that the participants disliked or thought unfavourably about. These have been amalgamated with the features listed by participants in the interactive gesture recognition tools study. Any features presented by the five participants who participated in both studies were only included once.

The features of the LIDS pen that participants disliked or commented unfavourably about are summarised in Table A6.2 (see the first appended list for a full list of these). An analysis of the responses is presented below.

The most common feature that participants disliked or made negative comments about related to difficulties using the LIDS pen. Six participants commented in general terms about the pen being difficult or uncomfortable to use. Eight participants commented on the difficulties experienced writing with the pen, including the need to take care when writing, the poor quality of the text, and the lack of concurrence between what is presented and what had been drawn or written (especially when the participant went too fast). During the interactive gesture recognition tools study, one participant commented on the response of the pen:

> *"When you click on somewhere on the screen and you've got to wait for it to come over. If you start drawing, and its still chugging away, the pen seems to jump to where you are. If you've got half way through a line it jumps to part way down." (P6)*

A number of participants disliked or commented negatively about aspects of the technique for using the LIDS pen correctly. Four participants commented on the need to maintain contact between the pen and the screen. Five participants commented on the angle at which the pen had to be held, including the need to hold the pen horizontal when writing or drawing. Three participants commented on the need to apply consistent pressure when writing or drawing.

Twelve participants disliked or commented negatively on the pen size. These ranged from general comments about the LIDS pen being too big to more specific comments about the pen being too large to hold. Six participants commented on the shape of the pen including that it was not ergonomically designed, that it was not difficult to hold or that it was different to their normal grip. Three participants found the LIDS pen difficult to control because of its size and shape.

Four participants made negative comparisons between the LIDS pen and other types of pens. One participant thought that the LIDS pen was more fragile than a whiteboard pen. Another participant thought the LIDS pen was harder to write with than a whiteboard pen. One participant felt that it would be better if the LIDS pen felt more like a conventional pen. One participant said that he would have preferred a whiteboard pen.

Four participants disliked the noise that the LIDS pen makes when in use. Other aspects that participants disliked or commented negatively about include the colour of the pen and the fact that the LIDS technology supports using only one pen at a time at a screen. Two participants commented negatively on the reliability of the pen, after technical difficulties they experienced with the pen in their session.

**Suggested Improvements to the LIDS Pen**

Question 23 in the summary questionnaire of the interactive gesture recognition tools study asked participants to identify any features that they would like to see in future versions of the LIDS pen. Some participants did not answer this question and others provided more than one response.

This question was not asked in the summary questionnaires for the shadow technology study. However, the questionnaires had a question that asked participants to identify features that they would like to see in future versions of the LIDS screen. In answering this question some participants made suggestions about the LIDS pen. These suggestions have been incorporated with those of the interactive gesture recognition tools study. Any features presented by the five participants who participated in both study have been included only once.

The suggestions made by participants about features that they would like to see in future versions of the LIDS pen are summarised in Table A6.3. An analysis of these features is presented below.

| *Improvements* | *No. of responses* |
|---|---|
| Pen size and shape | 7 |
| Pen response | 3 |
| Other | 5 |

*Table A6. 3 Suggested improvements to the LIDS pen.*

The most frequently mentioned feature for future versions of the LIDS pen related to the size and shape of the LIDS pen. In particular, four participants suggested making the pen smaller. In addition, one participant suggested having a range of pen sizes to suit different sized hands. Two suggestions related to holding the pen, with one participant suggesting improving the surface material of the pen for ease of holding.

Three participants suggested improving the interaction with the pen, making the pen more like a whiteboard pen or a mouse click.

Other features that participants identified included changing the nib of the pen to be more slanted, and removing or reducing the noise associated with the pen. Two participants suggested incorporating a laser beam as a cursor or pointer. One participant suggested adding more pen colours.

**Overview of the LIDS Pen**

In general, participants felt that the LIDS pen was not complex or unfriendly and that it was reliable. The participants generally found the LIDS pen easy to use and that using the pen became easier with continued use. The participants generally found it easy to write on the LIDS screen using the LIDS pen.

There are, however, some constraints to using the LIDS pen successfully: the pen need to remain in contact with the LIDS screen, the pen needs to be held near-horizontal, and the movement of the pen should not be too fast. At times, participants found it difficult to produce text of reasonable quality. Some participants suggested improving the interaction with the pen.

Participants were spread in their views on whether the pen was comfortable to use. A number of participants commented negatively on the size and shape of the pen, and a number of participants identified this as a feature they would like to see improved in future versions of the pen. Given that the pen need not be the size it is, it would be worth developing a smaller-sized pen.

## A6.3 Use of the LIDS Screen

The following sections present the results of the part of the LIDS studies concerning the use of the LIDS screen. These include the participants' perceptions of the LIDS screen, features about the LIDS screen that they liked and disliked, and suggested improvements to the LIDS screen. Any comments made by participants in the summary questionnaires are presented in Appendix 2.

**Participants' Perceptions of the LIDS Screen**

*The Interactive Gesture Recognition Tools Study*

Question 15 in the summary questionnaire for the interactive gesture recognition tools study asked participants to use a seven-point scale to record their feelings about nine aspects of the LIDS screen. Each scale consisted of a pair of extremes: complex – simple, low tech – high tech, unreliable – reliable, complex to use – easy to use, unfriendly – friendly, unattractive – attractive, low quality – high quality, dislike – like, fragile – durable. In our data analysis we have assigned a value of 0 to the midpoint of each scale, negative values moving towards the left-hand extreme of each pair (-1, -2, -3), and positive values moving towards the right-hand extreme of each pair (1, 2, 3). All participants completed this question.

The distribution of responses for each of the nine scales used in question 15 is illustrated below in Figure A6.5. Participants' perceptions of the LIDS screen were favourable. They all liked it. Most participants felt that the LIDS screen was simple, reliable, easy to use, friendly, high tech and durable.

The participants were more varied in their perceptions of the quality and attractiveness of the LIDS screen. Four participants thought it to be of high quality and two were ambivalent. Three participants felt it was attractive, two were ambivalent and one felt it was unattractive.

*The Shadow Technology Study*

The summary questionnaires for each of the three tasks in the shadow technology study asked participants to use a seven-point scale to record their feelings about eight aspects of the LIDS screen. The numbering of the questions varied between the summary questionnaires for the tasks. Each scale consisted of a pair of extremes: complex – simple, low tech – high tech, unreliable – reliable, complex to use – easy to use, unfriendly – friendly, unattractive – attractive, low quality – high quality, dislike – like. In our data analysis we have assigned a value of 0 to the midpoint of each scale, negative values moving towards the left-hand extreme of each pair (-1, -2, -3), and positive values moving towards the right-hand extreme of each pair (1, 2, 3). All participants completed this question.

The rating values over the three tasks were aggregated over all participants for each scale. Not all participants provided a response for each scale. Of seventy-two possible responses for each scale, the number of responses varied between seventy and seventy-two.

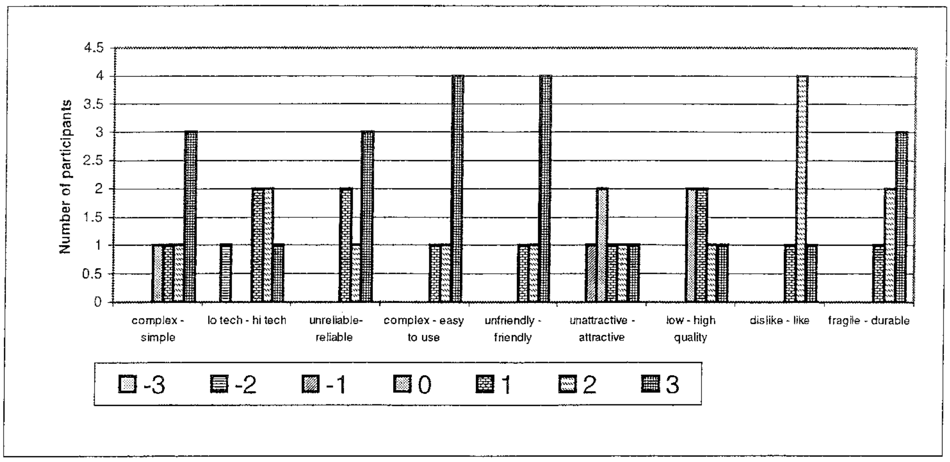


*Figure A6. 4 Participants' perceptions of the LIDS screen (interactive gesture recognition tools study).*

Individual participants were reasonably consistent in their responses over the three summary questionnaires. In one hundred and seventy-four (of the one hundred and ninety-two possible) cases, the three ratings were the same or varied by one rating point on the seven-point scale. Of the remaining eighteen cases, the three rating values varied by two rating points in twelve cases and by more than two rating points in six cases.

The distribution of responses for each of the eight scales is illustrated below in Figure A6.5. Participants' perceptions of the LIDS screen were favourable. They all liked it. Most participants felt that the LIDS screen was simple, reliable, easy to use, friendly, high tech and of high quality. For each of these attributes, most participants were clustered around rating values of 2 or 3. Participants were more varied in their perceptions of the attractiveness of the LIDS screen.

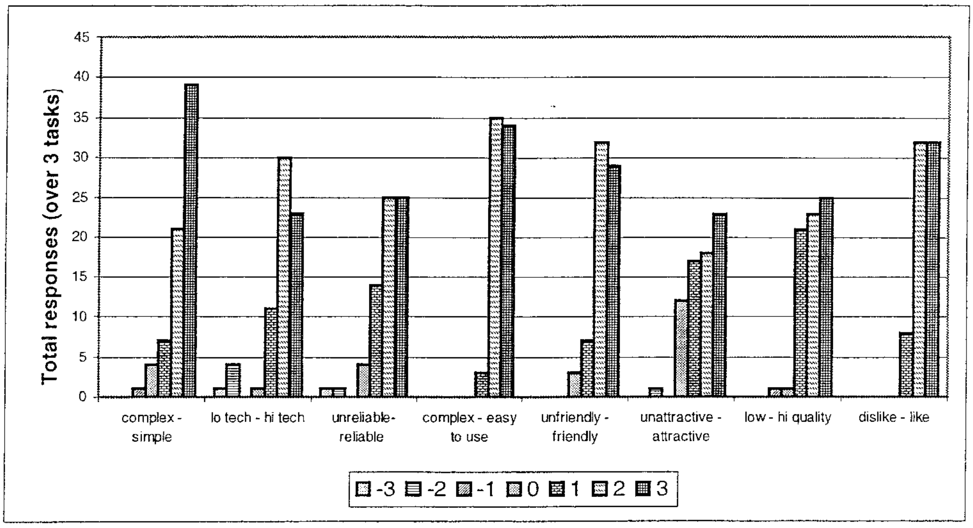


*Figure A6. 5 Participants' perceptions of the LIDS screen (shadow technology study).*

Other aspects of the LIDS screen that participants liked included the smoothness of the screen, the ability to annotate slides, the unlimited availability of slides, and that the LIDS technology did not require using a mouse.

Participants also liked aspects that related specifically to the nature of the task in the shadow technology study. Two participants liked that the LIDS technology could be used in a distributed environment. Three participants liked the communication features of the LIDS technology.

Question 14 of the summary questionnaire of the interactive gesture recognition tools study asked participants to list three things they disliked about the LIDS screen. This question was also asked in the summary questionnaires for the shadow technology study. The numbering of the question varied between the summary questionnaires for the tasks.

The responses made to this question in both studies have been combined and are summarised in Table A6.4 (see the second appended list for a full list of these). Not all respondents provided three items. Any features presented by the five participants who participated in both studies were only included once. An analysis of the responses is presented below.

One of the most common features that participants disliked related to screen resolution. Five participants stated this generally in terms of low screen resolution or blurred images. Eight participants disliked the size of the text that writing with the LIDS pen produced. Aspects of the text size that participants disliked were the thickness of lines, the requirement to write or draw to at least a certain size, the inability to produce text of a small size, and the displacement between the LIDS pen and the image on the screen.

The other most common feature that participants disliked was the readability of the LIDS screen. An important aspect of this related to lighting. The lack of contrast between the projected image and the room lighting, made the screen difficult to read, as did the reflection of the room lighting in the glass screen. One participant felt that the LIDS screen was too bright for her eyes. Participants also found the LIDS screen was difficult to read or that the colours distorted or changed from close up or at an angle.

Another aspect of the LIDS screen that some participants disliked was the screen size. One participant felt that the LIDS screen was too small and needed to be bigger. In contrast, six participants disliked the large size of the screen. One participant felt that the large size could obscure what was at the edges of the LIDS screen, so that it would be easy to overlook material, particularly at the periphery. One participant disliked that you have to stand when using the LIDS screen, and another participant found the height of the LIDS screen difficult to work at. Two participants felt that the large size could be a problem for portability and storage.

Three participants disliked the likely cost of the LIDS screen. They felt that it was too expensive for personal use, especially as it required a computer. Two participants disliked the response of the software and felt that it needed to be faster.

Other aspects of the LIDS screen that participants disliked included the smoothness of the surface of the glass screen, the colour of the screen, and that the system is not WUSIWIG. Specific to the PowerPoint presentation, participants also disliked the appearance and disappearance of the Start button in the bottom left-had corner of the LIDS screen, the presence of pencil icon of the projected image, the inclusion of multiple copies of the same slide in a PowerPoint presentation as a consequence of navigating through the presentation and the inability to see a range of slides at once.

Participants also disliked aspects that related specifically to the nature of the task in the shadow technology study. One participant disliked that the placement of the audio control on the frame of the LIDS screen. Another participant felt that the use of the LIDS technology in a distributed environment was difficult for multicultural groups.

**Suggested Improvements to the LIDS Screen**

Question 16 in the summary questionnaire of the interactive gesture recognition tools study asked participants to identify any features that they would like to see in future versions of the LIDS screen. This question was also asked in the summary questionnaires for the shadow technology study. The numbering of the question varied between the summary questionnaires for the tasks.

The responses made to this question in both studies have been combined and are summarised in Table A6.5 (see the second appended list for a full list of these). Not all respondents provided three items. Any features presented by the five participants who participated in both studies were only included once. An analysis of the responses is presented below.

Two participants commented generally on the usefulness of the LIDS screen, viewing it as a product with commercial potential or as a large shared work surface.

| *Improvements* | *No. of responses* |
|---|---|
| Screen readability | 8 |
| Screen resolution | 7 |
| Other | 6 |
| Speed and reliability | 2 |

*Table A6. 5 Suggested improvements to the LIDS screen.*

The most frequently mentioned feature for future versions of the LIDS screen was improved screen readability. This varied from generally making the screen easier to read to removing the glare or reflectivity of the screen (for example, by tinting) to changing the lighting. One participant suggested incorporating a brightness contrast on the LIDS screen.

Participants also suggested improving the screen resolution. This could include reducing the thickness of lines on the screen, providing the ability to write or draw smaller, and improving the image alignment on projection.

Physical features that participants suggested incorporating include increasing the size of the screen, giving the screen a more attractive frame, having a less smooth screen, introducing the ability to tilt the screen (up or down) and producing a more portable version. Participants also suggested removing the pen icon from the projected image. They would also like to see faster, more reliable software.

**Overview of the LIDS Screen**

In general, participants felt that the LIDS screen was simple, reliable, easy to use, friendly, high tech and of high quality.

Some limitations associated with using the LIDS screen are image resolution and the readability of the screen. The issues raised earlier by participants about screen resolution and readability were borne out in the observations of sessions for both studies.

In addition, it was observed that during the interactive gesture recognition tools study, two participants experienced difficulties in getting lines to meet when drawing or writing on the LIDS screen. In both cases, when the participant tried to touch up their drawing or text they gave up because they could not achieve the result they wanted. When one participant was asked about this, she said that she had found it quite hard.

During the interactive gesture recognition tools study, one participant chose to write in block capitals because she felt that it was easier and looked better. At one time, she tried to draw a dot but could not get it to work. To achieve the effect of a dot she had to draw a small circle and fill it in.

During the observations of the sessions for the interactive gestures study, it was noted that one participant appeared to have difficulty while working at the LIDS screen. The participant was reasonably tall and had to bend over quite dramatically to write on the lower half of the screen. It was also noted in observing sessions for the shadow technology study that some shorter participants had difficulty reaching the upper part of the LIDS screen.

Participants perceived the attractiveness of the LIDS screen to be more of an issue. For successful commercialisation, the LIDS product will need to be made more attractive. It may also be necessary to consider aspects related to the height of the screen.

## A6.4 Appended List 1: List of Participant Comments about the LIDS Pen

This appendix presents a summary of various comments made by participants in completing the questionnaires as part of the interactive gesture recognition tools study and the shadow technology study. The comments relate to the LIDS pen, and provide a useful source of quotes to illustrate the results presented in this report.

For the questions relating to participants' experiences with the LIDS pen, the participant number appears in brackets after the comment. In addition, the comments from the shadow technology study also have a T1, T2 or T3 to indicate the task summary questionnaire (task one, two or three) the comment was made in.

For the likes, dislikes and improvements, the participant number appears in brackets after the comment. To distinguish between participants in the interactive gesture recognition tools study and those in the shadow technology study, the former are preceded by a 'G'. Comments are grouped by into likes, dislikes and improvements.

**Interactive Gesture Recognition Tools Study**

Question 17: I found the LIDS pen easy to learn and use

- a lot like using a mouse (P4)
- easy to use when drawing; more difficult wrt creating text (P5)
- did not push hard enough at times (P6)

Question 18: I found that with use the LIDS pen became easier to use

- I soon discovered the right amount of pressure to use (P4)
- especially wrt to creating text; once I was used to amount of pressure I needed to apply, it became easier to do (P5)

Question 19: I found that the LIDS pen inhibited my ability to present my story

- problems I encountered were text related; creating images easy to do (P5)

- colouring in difficult (P6)

**Shadow Technology Study**

Question: I found the LIDS pen comfortable to use.

- pen reliable (P1, T3)
- pen too big; not easy to grasp (P2, T1); too big to handle, user must hold it horizontally (P2, T2)
- pen comfortable & easy to use (P3, T1)
- pen bulky, could be smaller (P4, T1)
- like a normal pen but doesn't run out or smudge (P5, T1)
- pen easy to grip & use on screen (P6, T1)
- difficult to draw neatly, had to be careful in making contact, pen big & heavy (P7, T1); more experience in use (P7, T2)
- pen big & comfortable, easy to write with (P8, T1)
- pen nice to use (P9, T1)
- no different to normal pen but bigger (P10)
- bit more uncomfortable to use; it went wide (P11, T@)
- it was easier this time but the marks I made were smaller (P13)
- good size & similar feeling to whiteboard marker (P14)
- is a new tool; was strange to hold; is different from my normal grip (P15, T1); not comfortable to write with (P15, T3)
- but only used for short period; would need to be smaller to be comfortable for longer term use (P16, T1); prefer smaller pen - a bit bulky (P16, T2); needs to be smaller (P16, T3)
- like using pen & paper (P17, T1)
- prefer a smaller pen (P18, T1)
- at times pen feels too big (P19, T1); getting used to it (P19, T2)
- fitted my hand quite well (P20)
- felt like a whiteboard pen (P21, T1); didn't use the pen in this task (P21, T2); pen in other room unreliable at times (P21, T3)
- pen has to be at the right angle; seems more fragile than a whiteboard pen (P22, T1); sometimes found it difficult to keep it straight (P22, T2); felt comfortable but was hard to write with cf whiteboard pen (P22, T3)

- normal whiteboard pen would have been better (P23, T1)
- rather too large; could be smaller; people with small hands may have difficulties (P23, T1); pen was good to use; programme didn't follow my movements => I go frustrated (P24, T2); used just as any other pen (P24)

Question: I found it easy to write on the LIDS screen with the pen.

- pen smooth and reliable (P1, T3)
- must hold pen horizontally (P2, T1); not easy to handle (P2, T3)
- must remember to apply consistent pressure (P3, T1)
- if movement too fast or pen at angle => letters untidy (P4, T1); symbols were large & easy to draw
- fairly quick and efficient (P6, T1); on screen line drew about 0.5cm above where you placed the pen (P6, T2)
- difficult making contact with screen (P7, T1); practice easier (P7, T3)
- not too much pressure needed to write (P8, T1)
- difficult to get a decent grip & draw how I wanted to (P11, T2); had to make that I applied pressure & did the correct commands (P9)
- the pen in this room was funny (P12, T2)
- I didn't use the pen in this exercise (P13, T1)
- as long as you keep contact (P14)
- easy to write 1 letter; more like a stick than a pen (P15, T1); easy to write with but control lacking bcs of enforced grip (P15, T3)
- much easier if I placed my hand against screen (P16, T1); too bulky (P16, T3)
- like using a whiteboard (P17, T1); like using pen and paper (P17, T3)
- hard to remember to take care writing (P18; T2)
- don't have to push pen too hard (P19, T1)
- holding the pen at angles to the screen doesn't feel as natural as I thought it would (P20, T1)
- didn't use the pen in this task (P21, T2)
- need to get used to having pen firmly in contact with screen (P22, T1)
- just like using a whiteboard pen (P24, T3)

**Likes**

Ease of use

- easy to use (see what was happening) (GP1)
- easy to use (GP4)
- easy to use (P3)
- pen easy to use on screen (P6)
- pen nice to use (P9)
- ease with which can create images (GP5)
- easy to handle (didn't encumber task) (GP5)
- easy to write with (P8)
- easy to write with (P15)
- it was easier this time but the marks I made were smaller (P13)
- generally responsive (GP1)
- worked on most angles (GP6)

Pen size

- good size (P14)
- good size to hold (GP4)
- pen big & comfortable (P8)
- pen not heavy (GP2)
- size appropriate for task (GP5)

Pen shape

- comfortable pen/board (P21)
- pen comfortable (P3)
- pen comfortable (P8)
- pen easy to grip(P6)
- fitted my hand quite well (P20)
- suitable for me to hold (GP2)

Positive Comparisons

- similar feeling to whiteboard marker (P14)
- felt like a whiteboard pen (P21)
- just like using a whiteboard pen (P24)
- like using a whiteboard (P17)
- no different to normal pen but bigger (P10)
- like a normal pen (P5)
- like using pen & paper (P17)
- more like a stick than a pen (P15)

Using the pen

- not too much pressure needed to write (P8)
- don't have to push pen too hard (P19)

Other

- does not run out (P5)
- durable (can write forever) (GP2)
- does not smudge (P5)
- colour of it ok (GP1)
- different colour options (P15)
- smooth (P1)
- fairly quick and efficient (P6)
- pen reliable (P1)

**Dislikes**

Difficulties of use: Pen use in general

- bit more uncomfortable to use; it went wide (P11)
- not comfortable to write with (P15)

- pen a little hard to use (P22)
- not easy to handle (P2)
- pen not good enough (P2)
- much easier if I placed my hand against screen (P16)

Difficulties of use: Writing with pen

- had to remember to take care writing (P18)
- my partner found it difficult to write (P13)
- difficult to write neatly (P6)
- didn't always draw exactly what I wanted (sometimes missed lines) (GP1)
- programme didn't follow my movements => I got frustrated (P24);
- if moving too fast or pen at an angle, pen would only draw part of line or get untidy letters (GP6)
- on screen, line drew about 0.5 cm above where you placed the pen (P6)
- colouring in difficult (GP6)

Difficulties of use: Maintaining contact

- difficult to draw neatly, had to be careful in making contact (P7)
- as long as you keep contact (P14)
- difficult making contact with screen (P7)
- need to get used to having pen firmly in contact with screen (P22)

Difficulties of use: Angle of pen

- having to keep the pen straight (P22)
- user must hold it horizontally (P2)
- pen has to be at the right angle (P22)
- need to hold pen at right angle (GP2)
- holding the pen at angles to the screen doesn't feel as natural as I thought it would (P20)

Difficulties of use: Consistent pressure

- requires consistent pressure to create text of consistent quality (GP5)
- had to make sure that I applied pressure (P9)
- might be hard for some to push pen to draw (GP2)

Difficulties of use: Pen size

- pen too big (P17)
- too big to hold (GP3)
- pen too big to handle (P2)
- too large to hold easily (GP6)
- at times pen feels too big (P19)
- pen big & heavy (P7)
- pen too bulky (P16)
- bulky (GP1)
- could be lighter (GP6)
- prefer a smaller pen (P18)
- too large; could be smaller; people with small hands may have difficulties (P23)
- pen is cumbersome (P13)

Difficulties of use: Pen shape

- not ergonomically designed (GP3)
- pen might be hard to hold for a long time (GP2)
- pen not easy to grasp (P2)
- is different from my normal grip (P15)
- was strange to hold (P15)
- difficult to get a decent grip & draw how I wanted to (P11);
- can't control pen well when writing something (P17)
- pen is too smooth to control it (P17)
- control lacking because of enforced grip (P15)

Pen noise

- noise of pen when writing (P17)
- buzz is a little irritating; pen makes a nasty noise (P13)
- noise of pen (P13)
- squeaky noise when writing (GP3)

Comparisons

- normal whiteboard pen would have been better (P23)
- seems more fragile than a whiteboard pen (P22)
- felt comfortable but was hard to write with cf whiteboard pen (P22)
- better if the feel was more like a regular pen (P23)

Other

- grey as default colour (P15)
- can't use more than one pen at a time (P19)
- pen in other room unreliable at times (P21)
- the pen in this room was funny (P12)

**Suggested Improvements**

Pen size and shape

- pen size (P15)
- smaller pen (P16)
- make pen less bulky (GP1)
- smaller pen (GP3)
- different size pens (to suit different hand sizes) (GP2)
- surface material of pen improved for easy holding (GP3)
- pen grip (P15)

Pen response

- make interaction with pen simpler (P13)
- make pen more responsive/more like a whiteboard (P13)
- make pen like mouse click (P17)

Other

- slanted nib on pen (rather than square) (P15)
- does the pen need to sound like an angry wasp (P13)
- use of a laser as the cursor (P22)
- red laser beam to point to presentation (GP3)
- more pen colours (GP1)

## A6.5 Appended List 2: List of Participant Comments About the LIDS Screen

This appended list presents a summary of various comments made by participants in completing the questionnaires as part of the interactive gesture recognition tools study and the shadow technology study. The comments relate to the LIDS screen, and provide a useful source of quotes to illustrate the results presented in this report. The participant number appears in brackets after the comment. To distinguish between participants in the interactive gesture recognition tools study and those in the shadow technology study, the former are preceded by a 'G'. Comments are grouped by into likes, dislikes and improvements.

**Likes**

Ease of use: Easy to use

- easy to use (GP4)
- easy of use (P15)
- easy to use (P18)
- easy to use (P18)
- easy to use (P21)
- easy to use (P1)
- easy to use (P2)
- simple - only few commands (P6)
- easy directions (P24)

- easy to see changes (GP1)
- easy to move around (GP5)

Ease of use: Easy to write

- easy to put ideas down knowing you could change them (P14)
- easy to write on (P21)
- easy to write (P17)
- easy to write on (P24)
- like writing on a whiteboard (P19)
- like whiteboard; can easily write on (P10)
- same as using a whiteboard (GP6)
- being able to write on what is effectively a computer screen (P20)
- symbols were large & easy to draw

Ease of use: Easy to erase

- erase easily (P17)
- easy to correct mistakes (P13)
- can clean without eraser (P12)
- don't need to clean it (P8)

Size of screen: Large screen

- nice and big (GP4)
- nice and large (P24)
- big
- big (P10)
- large area (P13)

Size of screen: Visual clarity and ease of reading

- large screen=>easy for audience to see (P16)

- suitable for audience of moderate size (P5)
- large and easy to read (P20)
- easy to see big picture (GP1)
- easy to read (P15)
- easy to see what we had to do (P21)
- nice & big => clear (P23)
- easy to read (P24)
- visual clarity (P3)
- easy to see writing (P5)
- clear (P6)
- easy to see what we had done (P13)

Size of screen: Room to write or work

- large space to write (P17)
- room to write
- size of screen prefect for creating a presentation; sufficient room for text & images (GP5)
- nice & large (>1 person can work at it ) (P3)
- large area for working on (P13)

Enjoyable

- enjoyable to use (P15)
- essentially fun (20)
- fun to use (P11)
- fun interacting (P14)
- very interactive (P19)
- interactive (P10)
- interactive (P11)
- friendly (P2)
- simplicity (P17)

- modern (P11)
- looks good (P18)
- attractive (P2)
- bright (P24)
- effective (P2)

Reliability

- reliable (P2)
- works efficiently (P2)
- didn't crash (P16)

Response

- fast; not much lag time (P15)
- fast (P10)
- immediate response to changes (GP1)

Other

- pen and screen smooth (GP2)
- work on prepared slide (P11)
- being able to draw on screen (P9)
- computer screen changes easily (P10)
- can overlay computer graphic or slides (P4)
- lots of slides so you never run out (P5)
- no mouse clicking (P12)

Aspects of shadow technology

- distributed use (P16)
- distributed use (P17)
- easy to communicate (P13)

- communication features (P18)
- talk to other user (P11)

**Dislikes**

Screen size: Screen too big

- size could obscure => miss stuff at edges (P6)
- screen size may be sized (P12)
- need to stand when using it (P17)
- the one in the HCI lab was very tall for squirt like me (P13)
- not very mobile (P5)
- size => difficult for use & storage (P6)

Screen size: Screen too small

- screen too small; prefer an even bigger screen (P16)

Screen resolution: Low resolution

- resolution (P15)
- low resolution (GP4)
- not sharp image; low resolution (GP3)
- not very clear (P2)
- screen blurry (P16)

Size of text

- can't write really small (P16)
- large lines when you write (p18)
- size of commands (large rather than small) (P15)
- promoted use of large hand writing (P18)
- drawing letters in box with large pen hard (P4)
- thickness of pen (covered most letters) (P15)

- on screen line drew about 0.5cm above where you placed the pen (P6, T2)
- need big drawings - difficult if you are poor at art or drawing (GP1)

Screen readability

- hard to read off (P22)
- difficult to see what letters were left at end of task (P21)
- sometimes needs to be brighter (P24)
- not that well lit (P24)
- reflection from lights (P21)
- hard to see with lights on (GP4)
- lights behind make it hard to read (P24)
- difficult to see when up close (P22)
- difficult to see from some angles (P2)
- too bright for my eyes (P17)
- haven't seen it in the sun (P8)
- always had a yellow background to the drawing colour chosen (& colour choices varied in availability) (GP1)
- black looked blue when close to screen (GP6)

Cost

- cost - too expensive for personal use (P17)
- looks expensive (P5)
- need a computer (P5)

Slow response

- updates need to be faster (P23)
- small delay between what I draw and what is displayed (P16)

Other

- pencil on the screen moves with pen movement (annoying) (P19)

- pencil on screen annoying (P22)
- glass - no friction on screen (less natural feeling than writing on paper (GP3)
- screen colour (P2)
- not WUSIWUG (p16)
- Start button appeared when tried to cross something out in bottom left corner (P20)
- records in the PowerPoint file all copies of same slide =>bigger file than necessary and one that requires editing (GP2)
- can't see a range of previous slides at one time (GP1)

Aspects of shadow technology

- audio control on screen frame (P10)
- difficult for transcultural groups (without visuals) (P11)

**Improvements**

General comments

- good product with commercial potential (P14)
- useful for proofreading documents (easier on eyes); able to share with everyone what you doing (P20)

Screen resolution

- resolution (P15)
- higher resolution (GP3)
- thickness of lines (P15)
- adjust thickness of lines (P19)
- ability to write/draw smaller (P16)
- more accurate pens (P21)
- more alignment on projection (P15)

Screen readability

- make it easier to read (P22)

- remove some of the glare (P22)
- non-glare (P8)
- less reflective (P21)
- change ligthing (P24)
- should have same effect when people see it from different angles (P2)
- tint (P8)
- adjust brightness contrast on screen (GP3)

Physical

- larger screen (P16)
- nice frame (P8)
- foldaway version (P6)
- ability to tilt screen (up/down) (GP6)

Faster, more reliable

- more reliable (fewer crashes) (P16)
- lines drawn faster to keep up with me (P16)

Other

- screen could be rougher to simulate writing on paper (GP3)
- remove pen icon on each line you draw (P15)
- video confirmation (p7)

# Appendix 7. LIDS Technical Problems

A number of technical problems were associated with LIDS over the three usability studies.

1. Start and Arrow button
   - The Start menu and the arrow button appear and disappear on slides in a seemingly random fashion.
   - In the Techonology in Use for Teachers and Students study, the Start button overlies the first word on the last line visible on the screen.
2. During one session of the Shadow Technology study, problems were experienced with the LIDS pen. This was attributed to the Mimio panel.

| *Session No.* | *Technology scenario* | *Problem description* |
|---|---|---|
| 8b | DNS | Trouble with pen in G1.31<br>System crashed; error message: could not read memory?<br>LIDS system in G1.31 closed down & Mimio panel reconnected |
| | DS | At end of the task, Mimio device in G1.31 died. |

3. Audio loop
   - During an attempted distributed meeting with AUT, the audio component of the LIDS technology went into a loop.
   - In three session of the Shadow Technology study (sessions 6, 9 and 12), the audio component of the LIDS technology went into a loop during the task in which the shadow was in use (Distributed with Shadow). A LIDS screen was set up in each of G1.15 and G1.31, which were in audio contact. Both rooms had speakers. The user in G1.15 used a headset, while the user in G1.31 held a microphone. The user in G1.15 was able to see the shadow of the user in G1.31.

| *Session No.* | *Technology scenario* | *Problem description* |
|---|---|---|
| 6 | DS | System in G1.15 crashed – could not read memory(?)<br>In first half of the task, audio loop error:<br>• looping of voice of participant in G1.31; could hear it in G1.15<br>Swapped rooms<br>G1.31 had a problem - PowerPoint contacting MS |

| | | |
|---|---|---|
| 9 | DS | At end of task, audio loop error;<br>• looping of voice of participant in G1.15<br>• "line 246" error on memory read<br>• scribbles and shadow unaffected in G1.15 & G1.31<br>Note: One participant's voice was very loud |
| 12 | DS | In first half of the task, audio loop error:<br>• looping of voice of participant in G1.31; could hear it in G1.15<br>• fixed by ignoring the error<br>Swapped rooms. System in G1.15 slow and then audio loop error:<br>• scribbles appear to be losing mouse data<br>• looping of voice in G1.15; couldn't hear anything in G1.31<br>• ignoring error caused an App Shutdown |

4. In the task in which the shadow was in use in the Shadow Technology study, a number of participants complained about the amount of material (namely, the shadow of the screen contents) present on the screen.

5. In a number of sessions, problems were experienced because PowerPoint was attempting to contact.Microsoft.

6. Other system failures in the Shadow Technology study were experienced.

| *Session No.* | *Technology scenario* | *Problem description* |
|---|---|---|
| 1 | DNS | Error message: "memory could not be read" in G1.15;<br>Problem in G1.31 – G1.15 lost pen response |
| 3 | DS | Assertion failure notification at beginning in G1.15;<br>Later system crashed or not responding |
| 4 | DNS | System in G1.15 appeared to crash |
| 5 | DS | Problem with system in G1.31 (?); screen in G1.12 locked up |

7. For incorporating audio, recommend using a wireless head set, rather than a headset attached by a lead to the LIDS screen.

8. Text in PowerPoint (from the Technology in Use for Teachers and Students study):

- The text was not always visible on the screen. (e.g. Lecturer had to write over the '/' in the URL, or '.' in class.method.)
- The text extended beyond the edge of the screen, both to the right and at the bottom.
- The Start button overlies the first word on the last line visible on the screen.
- Each line of the presentation has a (bullet point) dot next to it and some lines have a small square on them (representing tabbed characters). This may not be appropriate in all situations (e.g. if the text is code or if the presenter is fuss).
- When a slide first displays it is presented in a certain size font, then the hourglass is displayed, then the slide displays in another sized font (get a bouncing effect).

9. During one of the sessions in the Technology in Use for Teachers and Students study in which LIDS was being used for lecture delivery, it took over five minutes to move from one slide to the next. An error message then appeared indicating that the program was not responding. The lecturer abandoned the program.

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