MISPE – Mobile Information Sharing in the Presentation Environment

Brendan Fry, Dominic Gruijters, Stephen Reid
University of Cape Town
Cape Town
South Africa
+2721 650 3799
{bfry,dgruijte,sreid}@cs.uct.ac.za

ABSTRACT

While many studies have developed systems for use by students in educational settings very few of these systems can be implemented practically in a third world country like South Africa. Furthermore, the body of research into developing useful systems for educators and students is very small. This report outlines the design and implement of a high fidelity prototype system which will aid educators and students in performing work tasks.

The system described allows educators to distribute presentations via a wireless link to a client system. In addition educators are able to ask questions of students and also to answer student questions. Students on the other hand are able to receive the lecture slides, make annotations on these, ask question on these, answer lecturer questions and vote on lecturer polls. All of the above are done electronically across the wireless link.

This report also describes a research study that was conducted to ascertain the usability and usefulness of this system and also the abilities of the backbone support network. Naturalistic observations were conducted. The QUIS questionnaire for assessing usability was also administered to participants along with a questionnaire to assess the usefulness of the system. The network was tested by means of simulations.

It was found that the educators and students found the system to be usable and useful, while the network provides sufficient support to the client and server parts.

General Terms
Management, Performance, Design, Experimentation, Human Factors

Keywords
Presentations, PDA, Education, Usability, Naturalistic Observation, Smart Phone, Prototyping

1. INTRODUCTION

Computer use in education is becoming increasingly popular, and the use of mobile computing devices in the classroom is no exception. Large projects like Pebbles (**P**almPilots for **E**ntry of **B**oth **B**ytes and **L**ocations from **E**xternal **S**ources) are exploring the use of handheld computers for control and collaboration in such settings [1]. While these projects bring new ideas and technologies into the classroom most solutions are not viable in a South African context. The reason for this is that there is a technological device in South Africa [2] which requires bridging. The average South African student simply does not have access to the technology required for these projects to be put into practice.

Technology in South Africa is, however, not completely absent. South African is rumoured to have the largest proportion of cell-phones users in the world with just over 40% of the population owning a cell-phone and 80% of these users being active [3]. In order to bridge the technological divide in South Africa new systems and technologies must be brought to cell phones.

This paper describes a system which allows sharing and co-authoring of educational materials inside the classroom setting by using mobile computing devices. MISPE allows students to enter a classroom or lecture and connect, via a wireless link, to the teacher's or lecturer's computer. As the educators presents the materials to the class in the form of a slide presentation the student's PDAs receive the slides. Once the slide has arrived on the student's PDA they may annotate slides with pertinent information in much the same manner as they would usually annotate hard-copies of slides. Students may also ask and answer questions in an electronic manner.

The students are not the only ones that benefit, however. Educators can create and author questions and votes before hand using the system provided for educators. During class educators can display questions to students in the class as a slide and receive answers electronically. In addition lecturer's can display a vote or multiple choice questions and elicit electronic responses from students while watching the results appear in his/her slideshow in real time. Once the class is over, the educator can save all information created during the class (student answers, student questions and voting results). This will enable educators to better assess their presentation content.

The MISPE project has the following aims:

- To create a system which students can use to receive and annotate slides, as well as participate in classroom discussions and voting.
- Provide educators with a tool for authoring, creating, distributing, collecting and retrieving presentation materials.
- Connect the two systems via a wireless ad-hoc network using a combination of Blue-tooth and Wi-Fi technologies.
- Evaluate the student and educator systems for usefulness and usability.
- Assess the networks reliability and efficiency.

The problems that the MISPE system addresses are numerous. Firstly the client system addresses the problem of students being ill-equipped to effectively and efficiently collect relevant data during class time. The student's problem is compounded by having to rely on educators to provide copies of slides for use in adequate time. Secondly the system addresses the problem of educators not utilising the technologies available to them, to achieve their tasks as educators. While computers are used by educators both outside and during class time, educators use very little of the technologies available to them to carry out tasks such as asking and answering questions and collecting student feedback during lectures. Lastly, many mobile devices use numerous different methods of communication. This can become a problem in the classroom as devices using varying communication mediums can not communicate with one another hampering the information sharing process.

2. RELATED WORK

The Pebbles project has done a substantial amount of work in the areas of collaborative environments involving the distributing and sharing of various types of information. In [4], Myers describes various systems being developed by the Pebbles project. Among these is the *Slideshow Commander* which allows educators to run a PowerPoint presentation from his/her laptop while controlling the presentation from a PDA connected via a wireless link to the laptop. The PDA provides thumbnails of the slides available and allows the educator to move freely between slides using their PDA.

A system which allows multiple people to share an interactive whiteboard using PDAs is described in [1]. This system allows multiple contributors to take turns to use a pen or drawing device on a virtual whiteboard using PDAs to wirelessly access this single whiteboard display. *PebblesDraw*, as the system is named, allows users to take turns drawing on their PDAs and having their contribution appear on a single central whiteboard or display.

While these systems are useful in an educational context they supplement a very small proportion of the educator's overall workflow. This project differs from the systems developed by Pebbles by designing and evaluating a system that addresses more of an educator's workflow that just presenting information.

Systems which have helped create a more interactive learning environment are those that present students with an electronic, real-time voting system during lessons. Two studies have shown that such voting systems are likely to increase the participation of students in the classroom in comparison to conventional interaction methods [5 & 6].

In terms of authoring and creating presentation material [7] describes a tool which allows presenters to author materials that can be customised for specific members of an audience. This tool provides a server that serves customised presentation data based on the specifics of the audience members with relation to language, culture or disabilities. The tool provides no authoring capabilities in terms of questions or voting. In addition the system provides only one-way communication from lecturer to audience member. While this system mentions question capabilities on the client side no detail is given as to any implementation or testing of these features. In addition to this study, [8] executes two thorough studies to assess hypotheses related to educational theory. These two studies supported four hypotheses (to some degree of significance) which were, learners experience higher engagement in multimedia presentations which (1) are more challenging, (2) provide more feedback, (3) allow more presentation control and (4) vary in multimedia features.

Recent years have seen the advent of wireless network technologies. These technologies allow for data connectivity in ways that would not have been thought possible a few years ago.

Currently there is a vast body of research in the field of Ad-Hoc networks. Ad-Hoc networks are networks that are able to exist without a specific network infrastructure and without a fixed network topology [9 & 10]. They also do not require a central authoritative body. This makes them suited to a highly mobile environment where network nodes may come and go as they please [11].

3. METHOD

The methodology used to design the client and server systems was largely based on usability design principles. In order to assess the client and server systems a study involving a naturalistic observation of both students and educators was conducted. In addition to this the QUIS user satisfaction questionnaire was administered to students and educators.

3.1 System Design and Implementation

The overall system design consisted of the client PDAs connecting to the educators computer via a wireless ad-hoc network. Each system's design and implementation is discussed below.

3.1.1 Network Sub-system

The network module should take the form of a standardized reusable API. This will allow the client and server modules to be developed independently of the network module. It will also allow for the seamless replacement of the API as newer versions are developed.

The Network API should handle the transport of application data and leave the developers to concentrate on other aspects of the application development.

The developers of the client and server applications should not be required to spend their time dealing with the intricacies of network communications. By extension this leads to the end users who should also be freed from the requirement of being proficient in network communications.

In order for out system to maximize the type of devices that are able to access these sessions it is proposed that our system will include a client that is capable of bridging between the 802.11b network and a Bluetooth wireless PAN.

The Network module was developed as a pair of classes, namely NetworkClient and NetworkServer. The client was written to run on Microsoft Windows Pocket PC and the server on Microsoft Windows XP Professional SP1. These two classes were compiled to DLLs and distributed to the developers of the client and the server. Due to that fact the Network API interface had been designed at the beginning of the project incremental updates in the Network module required only distribution of new versions of the DLLs.

3.1.2 Server Sub-System

As stated previously the design of the system was largely user centred with a strong focus on users throughout the design process.

A very simple interface was produced and presented to three university computer science lecturers in a meeting setup for this particular purpose. Lecturers were asked questions on the interface and its constituent components. They were asked what they would expect certain components to achieve when used and also how they would go about performing certain tasks. In addition to this when a particular concept was misunderstood the participants were asked to suggest alternative designs in an ad-hoc participatory design fashion. The session proved to be somewhat challenging. While all participants involved understood the interface and its features, they were critical of the concept regarding the software. While the session yielded useful results and ideas for the developer some parts of the session proved unproductive as the pro's and con's of the idea of the system were discussed.

Once a paper prototype was completed a horizontal high fidelity prototype was developed. A high fidelity prototype is usually an interactive software version of the final system. This prototype is horizontal as it implements very few features but many of the interfaces proposed for the final system. This prototype was an evolutionary prototype and formed the basis of the final system.

The final step in the design phase was working with the horizontal prototype and developing it into the final system in the form of a high-fidelity vertical prototype. A vertical prototype implements many, if not all, of the features of the end system but may still be unoptimised and incomplete. These systems are excellent for use in full user testing and proof of concept of a new type of software. Due to the fact that the final product of the project was to develop a system to assess a particular concept a high-fidelity vertical prototype proved to be the ideal choice.

The system was implemented in C# and utilised automation through Microsoft PowerPoint in order to provide basic slideshow functionality. In addition all materials added to the system are added as slides into the initial presentation. This decision was made based on an educator's workflow being mainly centred on information display.

3.1.3 Client Sub-System

As stated previously discussed, the client sub-system was largely user centred. Due to this it was decided that the client would employ user centred design as its design methodology. This design methodology consisted of a number of keys steps that are discussed below.

The first phase of the design process involved the construction of user scenarios. These scenarios of the users' use of the system allowed us to decide on the key features of the system. This key feature list was then prioritised in terms of importance to the user and importance to the system as a whole. In this way both the user and system needs are thought about in the design process [12].

The next phase of design involved the creation of a low fidelity prototype of the system. This prototype was created to obtain user opinion and comments of the system. The results obtained from this section of design were comments made by the user, usage trends observed by the observer and a list of features that the users did not understand. With the use of these results the system's design was improved and a high fidelity prototype of the system was created.

As introduced above the next phase of the design process was the creation of a high fidelity prototype. This prototype was created using the same tools that would be used to create the final system. For this reason it looked very similar to the final system and users were able to get a feel for the features that were provided by the system and the way in which these features were provided. Here again user testing was conducted and the users were asked to perform a set of tasks. The users were observed conducting these task and notes were taken on problems that the users encountered. Users were again asked to comment on the use of the system with specific reference to the functionality that it provided and the way in which it provided this functionality. These results were used to refine the system design during the iteration of this phase.

The final phase of design was conducted in parallel with the previous two phases. This phase involved the creation small throw-away prototypes to learn the programming language that would be used to build the system. The second part of this phase was the construction of the communication protocol between the client and server systems. For this protocol the XML messages and classes to store the content of these messages were designed.

The system was developed in C# using the Visual Studio .NET Compact Framework. Using this framework a system that could easily be deployed to the PDAs was created.

3.2 Experimental Design

Two naturalistic observations were conducted to assess the usefulness and usability of the client and server systems as well as the efficiency and integrity of the network module.

3.2.1 *Participants*

Five educators (3 male and 2 female) were recruited as participants in the study. There mean age was 29 years old. Three were high school teachers and two were university lecturers. All participants were educators in some field of computing and reported a moderate to high level of computer experience.

Two of the educators volunteered a lesson each, so that educators and students could be observed in an actual classroom context. Two groups of students (one from each educator) were selected. The total number of student participants was 11 (5 in the first group and 6 in the second). The mean age of student participants was 18 years. All students reported having moderate computer experience and were all selected from the educators' computer related course.

3.2.2 Experimental Procedure

All participants involved gave informed consent to participate in the observations. The two educators scheduled lessons for the MISPE team to run their system during one of their classes. Students' interactions with the PDA system were observed and the educator's interactions with the system were also observed.

Observers recorded any unusual usages of the systems as well as common trends of normal usage. The observers were asked to collect data on user trends, features most used, comments made to friends and overall user reactions to the system. Observers were also asked to look out if the students were falling behind in the lecturer, or if they were able to effectively make annotations and ask and answer question while still listening to the lecturer. Observations of the educators specifically noted the normal teaching style and actions of the educator as well as when and how the educators interacted with the system and for which purpose.

After the class students and educators were asked to fill out a modified version of the QUIS user satisfaction questionnaire as well as an additional questionnaire used to obtain user opinion and attitudes towards the systems in question.

3.2.3 Equipment

The computer used for all trials in the contexts of both authoring and lecturing is as follows:

- Intel Pentium 4 - 2.4 GHz
- 512 MB RAM
- 160 GB Hard-disk Drive
- Gigabyte USB Wi-Fi IEEE 802.11b dongle
- 15" inch LCD flat-screen display primary display
- Dual-view graphics card
- Data video projector or CRT monitor for second display

The software specifications for the server system are as follows

- Microsoft Windows XP Professional
- Microsoft Office XP Professional (with PowerPoint)
- Microsoft Visual Studio .NET
- Microsoft Office PIA
- Microsoft .NET Framework 1.1

Students made use of the MISPE client system on HP iPAQ 4150 with the exception of one user who made use of a Compaq iPAQ 5500. These devices have the same configuration with the exception of the 5500 having twice the amount of RAM. The system performs adequately on both devises.

It was decided to use only the 802.11b connections and not Bluetooth. This was done because of the significant performance benefits of 802.11b over Bluetooth. As the users were also evaluating the client software it was decided that if the users were to connect using Bluetooth, it might detract from their experience.

4. RESULTS

4.1 Network Testing Results

The number of Data packets sent is the number of Data packets (Slides) in the session multiplied by the number of devices. The number of Data Packet Lost is the sum of all of the Data packets (Slides) that were not received by the clients.

Although the 6.5% data loss significant. More extensive error checking and the creation of a stronger network protocol would serve to further congest the network. Due to the limited power and bandwidth available on the mobile devices it was decided that 6.5% data loss was a sensible compromise.

Table 1 – Network efficiency results

Data Packets Sent	Data Packets Lost	% Loss
168	11	6.5
120	8	6.6

4.2 Educator Observation and Questionnaire results

The observation of users yielded interesting trends in user interactions and behaviours. These trends are discussed below.

4.2.1 System Latency

The single biggest negative effect on user performance when completing tasks was system latency when refreshing the slideshow. Since refreshes happen when selecting or deselecting materials to be added in the slideshow users often experienced latency and performed the action for a second time causing undesired effects or even undoing of the action.

4.2.2 Breaks in Workflow

Significant pauses in workflow were observed when educators responded to student questions during class or selected student answers to display on slides. This interaction with the computer was necessary to utilise the system during class time but still required a pause in the natural flow of the class in order for the educators to use the features available. The effect on the lesson was not drastic and pauses while educators were interacting with the system did not last longer than 10 – 15 seconds.

4.2.3 Use of Traditional Methods

It was observed that educators still relied heavily on traditional classroom methods even when the system was present. Some examples include educators still asking for opinions by asking for a show of hands and posing questions to the class verbally. In addition to this the natural technique of educators did not always place them close to the computer at the appropriate times. It was sometimes the case that the educator was moving around while giving the lesson and was not near the computer when a student question arrived to be answered. Educators tended to be near the computer when moving between slides and would often move away from the system to lecture/talk on that slide before moving back towards the computer to move to the next slide.

4.2.4 QUIS results

The scores ranged from 1 (the most negative response) to 9 (the most positive response). The average item mean was calculated to be 6.9 with a standard deviation of 0.95. Means were calculated for each individual item as well as means for each category of satisfaction. The table below lists the means and standard deviations for each major category. Table 2 shows the means for each item group in the QUIS.

Table 2 – Overall group means for QUIS results

Category	Mean	Std Dev
Overall user reaction	7.0	0.33
Screen	7.0	0.44
Terminology and System Information	6.6	0.6
Learning	7.4	0.32
System Capabilities	6.4	0.5

4.2.5 Results from Educator Opinion and Attitudes Questionnaire

Responses for the 23 Likert scale questions of this questionnaire ranged from 1 (the most negative response) to 7 (the most positive response). The mean item score was 5.8 with a standard deviation of 0.66. The mean score for each item was calculated as well as means for the entire categories of work task performance and attitudes and opinions. The mean score for work task performance items was 6.0 with a standard deviation of 0.53 while the mean score for the attitude and opinion items was 5.5 with a standard deviation 0.71.

In addition to these means the mean ranking for each work task was calculated. A mean was calculated for questionnaire items which were related to that particular work task. In other words questions 1, 2, 12 and 18 were related to displaying slides, so a mean was calculated over the mean of those items and associated with that category. Table 3 below show the rankings of work tasks by educators with the means of the associated items. A ranking of 1 indicates that the educator ranked the task as their most important work task whereas a ranking of 6 means the educator ranked the work task least important.

The items with the lowest (most negative responses) were items 23 and 13 with means and standard deviations of 3.6 (1.95) and 4.8 (0.98) respectively. The items with the highest (most positive scores) where items 1 and 2 with means and standard deviations of 6.5 (1.0) and 6.4 (0.5) respectively. Lastly, when educators were asked to indicate whether they would utilise the system on a scale of 1 to 7 (1 being seldom and 7 being often) a mean of 6 (standard deviation 1.0) was indicated

Table 3 – Results of educator attitude questionnaire

Educator Work Task	Related Questions	Mean Ranking	Mean of Related Questions
Answering Student Questions	8, 11, 13, 19, 23	1	5.4
Displaying Slides	1, 2, 12, 18	2	6.0
Distributing Slides	5, 6, 7, 13	3	6.2
Asking Questions	9, 10	4	5.2
Reviewing Student Input	3, 4, 16	5	5.8
Taking a Vote	14, 17, 20, 21, 22	6	5.9

4.3 Client Sub-System

Results for the client sub-system were obtained from the naturalistic observation and the QUIS questionnaire. Other than this a usefulness questionnaire was constructed and used, and the system was subjected to a heuristic evaluation. The results obtained from the above testing methods will now briefly be discussed.

4.3.1 Heuristic Evaluation

When subjected to a heuristic evaluation, the system performed very poorly, and received a number of critical errors from the evaluators. Upon receipt of these results, it was decided that another phase of design was necessary. In this phase the usability errors pin-pointed by the heuristic evaluation were fixed. Having redesigned the system it was subjected to a second heuristic evaluation. This time the system performed adequately with the evaluators only mentioning minor annoyances.

4.3.2 Naturalistic Observation

Results obtained from the naturalistic observation consisted of trends of user, features commonly used, comments made by users, statistics of system use and overall reaction to the system. Observers were also asked to observe if the users fell behind the lecturer or were able to keep up. The following trends were observed during the naturalistic observation:

- The users "played" a lot with the system when the lecturer was talking for a while on a specific point. Slow panning to follow the lecturer.
- Students asked a lot of questions knowing that the lecturer would not be disturbed by thee question.
- The authoring of annotations and questions took a long time, sometimes causing the student to fall behind the lecturer.
- Students became irritated when lecturer content such as slide were lost and not displayed.
- Students were excited when they on received answers or poll results from the lecturer. One student made a comment of how "cool" this was to his friend.

4.3.3 Questionnaire

Results obtained from the questionnaires were used to construct stem and leaf tables. From these usability and usefulness trends were observed. There were a number of interesting trends in the answers to the questionnaire. These trends involve bimodal distributions of user answers. Having analysed these results it was realised that the system crashes that occurred during the first test session negatively swayed user opinion of the system. Other bimodal distributions were attributed to the text that was used during the second set of user tests. This text did not display well on the PDAs and hence reduce the usability of the system.

Part two of the questionnaire dealt with the users' computer and mobile systems knowledge. Here it was seen that a number of the users had minimal mobile systems experience, this problem was anticipated with the design of the experience and to mitigate the effects of this the basic used of PDAs was explained to users before the test.

The means of the each section of the questionnaire can be seen in table 4. With each of the sections being of 9, the usability and results obtained show the system to be quite usable. It is seen that the overall mean of the usability questionnaire was 6.61 and the overall mean of the usefulness questionnaire was 6.13. These show the system to be well above average usability.

Table 4 – Questionnaire Results

Questionnaire Section	Average Score
3. Overall Reactions	6.28
4. System Screen	6.33
5. Terminology	6.78
6. learning	6.6
7. System Capabilities	6.26
8. Multimedia	7.4
Usability Average	**6.61**
9. Usefulness	6.13
Usefulness Average	**6.13**

5. CONCLUSION

This project set about to construct a system that would allows lecturers to author educational material and distribute these over a wireless network to the students' PDAs. The aims of the project were as follows:

- Develop a system that allows educators to create and distribute educational materials.
- Develop a system that allows educators to collect, store and retrieve educational materials created during teaching time
- Develop a system that would allows student to and receive lecturer materials.
- Develop a system that allows students to collect, store and retrieve educational materials by the lecturer and other students
- Assess the usability of the resulting system client and server.
- Assess the usefulness of the client and server systems and their effect on the users' workflow.
- The network module should take the form of a standardized reusable API.
- The network module should provide reliable network messaging
- The network module should make use encapsulation and hide the networking details for the systems using it.
- The network module should make use of a network bridge to transfer slides.

With the design, testing and final creation of the client and servers, the first four of the project aims were realised. A client system was created that allowed students to take part in the lecture, contributing lecture materials such as question, annotations and votes. Students were able to leave the lecturer with this educational content saved in a well formed format of the PDA. A server system was developed which addresses multiple and varied work tasks of educators. The system developed ensured that educators could create and distribute educational materials as well as collect, store and retrieve educational materials created during teaching time.

With the integration of the client, network and server modules the first three network based gaols were realised. A reliable and suitably abstracted network API has been created. It has been shown to function when fully integrated with the MISPE Client and MISPE Server. There was a degree of data loss but this was minimal (6.5%).

The two joint aims of the client and server were realised when the experimental study yielded results to that shows the systems to be usable and useful. Naturalistic observation and questionnaires yielded results which showed that the developed systems were useful and usable to the users. Analysis of these results showed that the system was usable and that many users had positive attitudes towards the usage of the system.

However, the systems were not without short-comings. As expected, educators were not able to give the system their full attention during class time and thus did not utilise the functionality to its full extent. Students were hampered by the speed of text entry of PDA, this often causing them to fall behind the educator. Having said this, the tasks which the users did perform were performed with efficiency and in a manner that suited their work flows well.

Unfortunately the creation of the 802.11b to Bluetooth Bridge was possible. Due to hardware limitations with the devices used (HP iPAQ 5550), the bridging client was unable to run correctly. The device was not capable of connecting to both an 802.11b access point and a Bluetooth PAN simultaneously. It is unfortunate that this was not possible as it would have greatly increased the ability of many different devices to connect to the system.

This project has therefore achieved the goals set out earlier by means of sound design and implementation and by experimental methods which were discussed earlier.

6. FUTURE WORK

While this project achieved its aims it was conducted on a fairly small scale thus yielded results that cannot easily be generalised to a wide variety of situations. For this reason, future research is required for the following reasons:

- To replicate and reconfirm the findings of the experiment in a wider variety of environments and circumstances.
- To improve on the solution presented in this report.
- To develop sound methodologies for assessing the usefulness of software of this type to educators and students.

Other improvements to the system and experiment will be discussed in the next three sections.

6.1 Longer time period of study and observation

In order to gain a better understanding of the long term impact of the system on an educator's and students' work flow further research is required. Future research should focus on carrying out a lengthier study to ascertain how educators and students utilise the system over a longer period of time. The results of such studies could provide findings this study was unable to, due to time constraints.

6.2 Further Improvements to the System

While the system was found to be useful and usable to educators and students it still requires improvement and refinements in certain areas. One of the key findings of this study is that educators are unable to give their attention to the software during class time. A possible improvement to the system may be to implement the control software on a mobile device so that the educator does not need to be close to his/her laptop during lessons in order to utilise the functionality which may be beneficial to their workflow. Students were hampered by the lack of scribble notes and the orientation of the slides, options for these should be provided.

6.3 Future Network research

Although we were prevented from implementing the bridging client we feel that it would have been possible if the hardware had allowed this. We feel that it would be advisable to continue investigation into this and to experiment with other hardware.

The usability of the system could be greatly enhanced buy the development of a true ad-hoc network that is independent of the technology used or the platform running on the mobile device.

If the system was to be widely used at a large institution such a schools or universities, the model could be slightly modified to incorporate a indexing server that would allow users to query any of the available sessions taking place and connect to them without prior knowledge of the session name.

In order to improve the efficiency of system broadcasts the server should identify the type of connection, i.e. Bluetooth or 802.11b and store this information alone with the IP information of the client. This would greatly improve the efficiency of broadcasts by the server.

7. REFERENCES

[1] Myers, B.A., Stiel, H., Gargiulo, R. Collaboration Using Multiple PDAs Connected to a PC. *Submitted for Publication.*

[2] Marsden, G. Using HCI to leverage communication technology. *Interactions 10, 2* (2003), ACM press, 48-55.

[3] Statistics of Cellular in South Africa. Available at http://www.cellular.co.za/stats/statistics_south_africa.htm.

[4] Myers, B.A. Using Handhelds and PCs together. *Communications of the ACM 44, 11* (2001), 34 – 41.

[5] Jones, M., and Marsden, G. "Please turn ON your mobile phone – First Impressions of Text-messaging in Lectures" *Mobile HCI,* 2004, Short paper. (Yet to be published)

[6] Draper, S.W., and Brown, M.I. Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning 20* (2004), 81-94.

[7] Hexel, R., Johnson, C., Kummerfeld, B., and Quigley, A. "PowerPoint to the People": Suting

the Word to the Audience. *Conferences in Research and Practice in Information Technology, 28* (2004), 49 – 56.

[8] Webster, J., and Ho, H. Audience Engagement in Multimedia Presentations. *The DATA BASE for Advances in Information Systems 28, 2* (Spring 1997), 63–77.

[9] *Decentralized Ad-Hoc Groupware API and Framework for Mobile Collaboration.* Proceedings of the 2001 International ACM SIGGROUP Conference on supporting froupwork, Session 1, p 5 – 14, 2001. By D. Buszko, W. Lee, and A. Helal

[10] *An on-demand minimum energy routing protocol for a wireless ad hoc network.* Mobile Computing and Communications Review, 6(2), July 2002. By S. Doshi, S. Bhandare, and T. X. Brown

[11] From Ad-Hoc Networks to Ad-Hoc Applications, Benoit Garbinato and Philippe Rupp

[12] Jenson, Scott. 2002. *The Simplicity Shift: Innovative Design Tactics in a Corporate World.* USA: Cambridge.