Harnessing GIS to Extend HCI Teaching

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Abstract

Visualization of information is an important human computer interaction (HCI) research topic but it is not generally included in university courses. Geographical Information Systems (GIS) are excellent examples of applications where visualization is used to represent information. In addition, GIS require sophisticated interfaces so that the users can manipulate and query the underlying data. Hence, in practical exercises using GIS students interpret information and use interfaces that differ somewhat from standard Windows objects and text. As this context and form of interaction is unfamiliar to typical Information Systems students, this experience can be exploited further to emphasize the fact that end users frequently operate outside their comfort zones when they use information systems. This paper describes a strategy to enhance the teaching of HCI. The learning experience takes the form of an HCI evaluation of GIS software in a usability laboratory. Students play the roles of end-users and researchers / evaluators. The exercise allows the lecturer to demonstrate exactly how usability data, including satisfaction questionnaires, can be collected and analyzed. As a result four separate objectives are met at one time, an important issue when lecture time is scarce.

Keywords

Geographic Information Systems, Graphical user interface, Human-computer interaction, Information Systems education, Software design and evaluation, Usability testing, Visualization of data

Introduction

'Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive comput-

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ing systems for human use and with the study of major phenomena surrounding them.' (Hewett *et al.*, 1996)

Human-computer interaction (HCI) studies the way in which information is presented, the way in which input mechanisms (the features that allow the end user to input data or select options) are understood and used, and the way in which a 'conversation' occurs between human and computer as the one responds to the other. HCI is considered to be a critical technology, which accounts for more than half the cost of new systems and is a significant factor determining whether software will eventually be adopted and used effectively (Strong, 1994; Douglas *et al.*, 2002). HCI is included as a core knowledge area in the Computing Curricula 2001 (ACM-IEEE Curriculum 2001).

'Universities should be encouraged to perceive HCI as a 'critical technology' and the accompanying skills and knowledge as fundamental to a student's education and preparation for jobs in the information age.' (Strong, 1994)

The ACM SIGCHI Curricula for Human-Computer Interaction (Hewett *et al.*, 1996) includes an Information Systems curriculum in HCI (as Appendix B of that document).

Increasingly HCI (in contrast with the broader field of Interface Design or Interaction Design where interaction with specially designed artifacts with control panels or other controls is important) is taught using Web-based systems as examples. This can be seen in the examples and emphasis provided in text books regarding GUI software interfaces (see Preece *et al.*, 2002; Carroll, 2002; Stone *et al.*, 2005; Newman & Lamming, 1995; Shneiderman & Plaisant, 2005). However, in practice it is necessary to design and evaluate interfaces of all sorts of software, ranging from that which does very little processing to sophisticated software development tools and customized application software, regardless of whether they are accessed from the Internet or are local. Obviously the complexity of the interfaces of these systems varies. On a straightforward Web page the user's input is generally limited to navigating using standard options. E-commerce sites require forms to be filled in and submitted but also increasingly use standard interaction features. In contrast, custom-developed applications may have a far larger number of input options, use unfamiliar conventions and be less consistent and predictable. Similarly the output, both in terms of the information presented and its format, can vary in complexity. At the same time the user may need to concentrate on demanding tasks in a stressful work environment and hence needs a transparent interface more urgently than a Web surfer does.

This paper will discuss how a graduate HCI course can address these issues by including as examples systems that use visualization to present rich information (large, information-abundant displays). Tools that construct visual representations of information not only produce output that assists the user in interpreting complex information, but also include features that allow complex input instructions to be constructed, and hence allow the user to interact in a sophisticated way with the system. Thus, the primary intention was to develop the students' understanding of interaction issues beyond the standard, familiar options seen on typical Web sites and e-commerce systems to those required on more complex applications to which they will have had less exposure. By demonstrating a wide variety of options the course will, hopefully, stimulate the students to be more creative when designing new systems. As will be seen two additional outcomes were achieved by studying the GIS software within a simulated usability laboratory.

This paper consists of the following sections.

- A section where the underlying learning theories and their application to the subject and learning environment are discussed.
- A section on visualization in which its importance to HCI is explained and the current problems regarding teaching visualization are noted.

- A section on usability testing. This is a topic which is completely separate from visualization but can be demonstrated using GIS software as the software being evaluated.

The case study, which is a detailed description of a series of lectures and a practical session, is then described in detail.

Learning Theories and their Application to HCI

Constructive Learning

The following characteristics of constructive learning are derived from those given by Simons ((in Duffy *et al.*, 1993) cited by De Villiers (1995, p.79)).

- The learner must be *actively* involved.
- The learner will interpret the new information in the *context* of existing information.
- The resulting knowledge will, therefore, extend existing knowledge as additional meaning is *constructed.*
- The learner must be aware of the *goals* towards which he is working.
- The learner must ensure that he is still on course and *progressing* towards the goal.
- The learner must be *conscious* of his way of learning.

There is no real reason why these requirements cannot be achieved in a lecture, but it is essential that the learners actively participate in the learning process. The lecturer can provide the learning opportunity but the co-operation of the learner is needed to ensure that this learning occurs. Constructive learning is particularly well suited for topics where relationships can be determined, multiple representations compared and a real-world context explored. It is not suitable for acquiring a fixed set of preordained, factual knowledge (Leidner & Jarvenpaa, 1995). Hence, constructive learning can be achieved best in HCI by using a problem-oriented educational approach where the students are actively involved in practical tasks. This is in line with the recommendations made by Gulliksen & Oestreicher (1998) and Strong (1994) but, as both groups of authors recognize, it is necessary to seek feasible ways of achieving these goals.

> '*How can we introduce practical tasks into a HCI task? Without it taking too much time? Using simple and realistic problems.*' (Gulliksen & Oestreicher, 1998)

> ' *There is also the challenge of a [sic] setting up a practical context and approach for getting students involved in real world projects. It is often very difficult to set up such situations in a lab.*' (Strong, 1994)

The Social Context of Learning

The social interaction of the individual is an essential part of learning and group work is intended to achieve this. Richmond (1970, p. 95) quotes Piaget as follows,

> *' "... without interchange of thought and co-operation with others the individual would never come to group his operations into a coherent whole ..." (Intelligence, p. 163.)'*

Socioculturalists believe that the ideal of the individual's subjective interpretation of reality being as close as possible to a universal objective reality is in fact neither possible nor, indeed, desirable. They emphasise that learners will only readily accept and understand concepts that they can relate to their own environments, cultures and histories. Each individual will have a unique interpretation of reality, which reflects his unique life world. Vygotsky emphasises a social origin for learning. Thought is a form of 'inner dialogue' modelled on interaction between people (Thomas, 2000). Learning is seen as a social process that involves human beings in communication with one another. Hence, teams should be made up of more advanced learners and less advanced learners so that the learners can learn from one another. This is, therefore, a model that fits in with an intersubjective view of social and physical reality rather than either a subjective or objective ontology. Despite the fact that both sociocultural learning theory and constructivism are both cognitive models, they differ with respect to how closely the subjective interpretation should coincide with objective reality.

Teamwork has been recommended as an important part of the activities in HCI courses with the students adopting roles in 'simulated development team(s)' (Strong, 1994; Gulliksen & Oestreicher, 1998).

'Classes should be broken into teams of four to six students, with each team member assigned a role on the team.' (Strong, 1994)

Visualization

Visual representations of complex data are found in numerous applications in fields as diverse as the health sciences, business and economic sciences, earth sciences and natural sciences. The potential for creating such graphic representations has grown as processing power and computer memory has increased. It is for this reason that visualization is one of the focal points of HCI research (Hartson, 1998). The Human-Computer Interaction Lab of the University of Maryland, for example, has numerous current and past projects where aspects of visualization are researched and they see larger, information-abundant displays as the future of user interfaces (Human-Computer Interaction Lab/ University Of Maryland; North & Shneiderman, 1999). The School of Information at the University of Michigan also has research initiatives in information visualization (Olsen *et al.* 1997). HCI is 'cross-disciplinary in its conduct and multidisciplinary in its roots' (Hartson, 1998) and it is, therefore, not surprising that GIS user interface issues and usability feature prominently as research topics in Geographic Information Science (Cartwright *et al.*, 2001; MacEachren & Kraak, 2001; Slocum *et al.*, 2001). Cognitive issues concerning construction and interpretation of visual representation are related research topics that also combine HCI with applications. This is very valuable when combined with data mining (Schoeman, *et al.*, 2003). .

Information Systems is the discipline where students learn to design computer systems and these may be intended for various application areas. These students need, therefore, to be prepared to address the requirements of the future in a wide range of applications. Gasen (1996) predicted the following HCI educational outcomes for the future (1996+).

TABLE I: HCI Educational Outcomes for the Future
Extract from HCI Education in Perspective (Gasen, 1996)

HCI in higher education	1996+
Educational Outcomes	Increased understanding of social needs
What do students learn?	Communication and information
Concepts: knowledge of parts	**Visualization very important** *(my emphasis)*
Skills: techniques for using concepts learned	Further emphasis on process
Processes: Ways of linking techniques, i.e. methods	Greater focus on iterative educational design, evaluation and accountability

There are not many books available that can be used in a graduate HCI course, particularly when studying the development process[1] (Gulliksen & Oestreicher, 1998). (Two are noted by Gulliksen & Oestreicher as being used predominantly in Sweden, namely Preece *et al.* – the newest edition is 2002, and Dix *et al.*, 1998). American university courses use a wider variety of texts (Strong, 1994) and many courses make use of collections of readings. Gulliksen & Oestreicher felt that the books were in general not entirely satisfactory. '... very few books that can be used on higher levels of education ... too shallow' '... no really useful textbook on the market.'

Those that are most often prescribed pay particular attention to general concepts and theories such as cognition, design and evaluation methodologies - such as user-centered design and iterative development - and HCI principals and heuristics. They often use examples from typical Web pages, computer-mediated communication and groupware, and from dedicated devices such as mobile phones but seem to neglect other software. It is understandable that they rely on examples that the average student is familiar with, but this tends to reduce the significance of the topic and limit its usefulness in preparing students for the full spectrum of applications that they will eventually encounter. The students may be left with only a superficial understanding and the impression that this is a very simple field of study, which is unworthy of the emphasis placed on it. In short, HCI is not simply about designing stylish web pages.

However, the new edition of the well-known book by Shneiderman goes some way to addressing the problem, as it includes a chapter on 'Information Search and Visualization' (Shneiderman & Plaisant, 2005).

Usability Testing

Laboratory testing to evaluate usability is one of a number of complementary methods of evaluating software interfaces. It can be used in both formative and summative evaluation to collect data, specifically times taken to complete set tasks and error frequency counts. It is a typically positivist method, and hence it can only be used as part of the software evaluation. As it takes place in a laboratory the setting and the tasks are controlled, independent and dependent variables are identified, and an attempt is made to exclude all other factors. Hence the participants who are using the software are not interrupted, do not work under undue pressure, and are not required to work for over-long times (unless the evaluation specifically includes one of these factors as a variable). These stress factors are often present when the software is used in the office and by excluding them the evaluation can be simplified and be made more rigorous. The data collected is largely quantitative as times are measured and errors are counted. These data can be collected automatically by building code into the software that records times, specific input, and error codes (Preece *et al.*, 2002).

The data can be supplemented by asking the participants to complete satisfaction questionnaires, which may include open-ended questions as well as questions that can be analyzed quantitatively. Additional information can be collected by recording the participants' actions on videotape and interpreting this information later. (For example, the recordings can be viewed to detect attitude by analyzing body language). Alternatively, the participants can be asked to explain what they are doing and why, while they carry out the set tasks and this can be recorded as audio, or they can be interviewed after they have completed the lab session.

Students taking our HCI course are told about various of ways of evaluating human computer interaction, including laboratory tests. The whole question of quantitative and qualitative evaluation is discussed in detail and a pluralistic evaluation plan is recommended.

Research Methodology

Since this paper presents a detailed description of a teaching case, this is not a research paper and we cannot claim to use a research methodology in a strict sense. The 'research' is at best exploratory, interpretive research and relies on description rather than on data of any sort.

However, since the author was personally involved as a participant and main decision-maker it can possibly be considered to be action research. The cycle of action, reflection, learning and revision, which is essential in action research, has subsequently become established as the initial presentation of the lectures and laboratory work has been repeated three times. However, this repetition has all taken place since this paper was initially submitted and is not described here. The data collection described in the section on the practical, laboratory session was not intended to collect research data but rather to illustrate to students how data is collected and analysed in a usability laboratory.

The Case Study

The Fourth Year HCI Course and Students

At our university the fourth year HCI course is one of ten, semester (fourteen week) modules taken by graduate Informatics students. The current class consists of one hundred and forty eight students, some of whom study part-time. This is the only course in the Informatics stream of the School of Information Technology that is devoted specifically to HCI. The course is mainly presented as lectures during which there is time for discussion and some workshop activities but practical classes in computer laboratories are also included where students evaluate different human computer interfaces. The students are not taught to use any web development software nor are they expected to implement designs using any programming language as this course concentrates on interaction design and evaluation. These students have, however, all completed programming courses and can be considered to be highly computer literate.

The students are introduced to HCI concepts while doing the analysis, design and full implementation of a system for a customer as part of their third year project. Design of web pages is also included in the implementation of an e-commerce system in a separate fourth year module, but not all of the students will have completed that particular course.

A graduate HCI course should reinforce these complementary learning experiences but also needs to go beyond them. It is difficult to cover all the recommended material adequately in the time available while including opportunities for active student participation. One needs to design the course and each lecture so as to get the maximum from it without overloading the students with more information than they can assimilate.

A paper (Yeh & Wickens, 2001) that describes a usability test of GIS software, during which the use of colour and intensity and decluttering features was evaluated, triggered this lecture plan. This piece of research was not presented as being intended specifically as an HCI learning opportunity but formed the stimulus for this exercise.

Lecture Preceding the Laboratory Session

The GIS laboratory session was preceded by a lecture presented by a cartography lecturer. He introduced the topic and demonstrated the use of two GIS systems, one of which is licensed software and one that is freeware. Hence the idea of visualization of information and the particular application in GIS was discussed and, since this lecturer actually demonstrated the task that made up the tutorial (see below) the students were given a clear explanation of the purpose and expected results of the exercise that they would do the following week.

Additional Preparation

Prior to the practical session the freeware (SIGIS available on www.sigisco.com/sigis/) was downloaded onto the computers in the laboratory together with the database provided for use in the tutorial. The site also provides detailed instructions for a tutorial and copies of this were printed. The tutorial was subdivided into tasks so as to provide a structured process with specific activities that could be associated with the data that was recorded. This made the analysis of the data easier.

The lecturer created:

- An instruction sheet in which the purpose of the exercise and the procedure to be followed was explained (Given as Appendix A),
- A satisfaction questionnaire,
- Some supplementary notes where she thought additional help might be needed,
- Sheets on which to record the observation data,

- Printed 'banners', which were placed on the computers to identify groups,
- Spreadsheet templates where the data collected during the usability test would be entered. It was an essential part of this exercise that the students themselves entered the data they collected into the spreadsheet (so that this task was not added to the work load of the lecturer). Therefore it was important to ensure that they clearly understood the structure of the spreadsheet and the data entry process.

Arrangements were made for a video camera and an assistant to make video recordings. The whole exercise was given the status of a group assignment and marks were allocated which contributed to the students' module mark.

The Practical, Laboratory Session

This session lasted for two hours. The purpose of the exercise was explained and the idea that this was intended to replicate conditions in a usability laboratory was emphasized. The students were told that it was not important whether the group completed the all the tasks or not and they were provided with all the material that had been prepared. The groups of students were then asked to work through the tutorial. One student took the role of observer and recorded times taken to complete tasks and any problems encountered on the observation sheets provided. The other two worked together as 'end users' (one as operator actually actively using the computer and the other as a consultant who read instructions and helped the operator to decide what to do). The lecturer remained in the class and gave encouragement and minor assistance but primarily tried to keep the process going. Although she was not making notes she was also observing the process and the video recordings captured some of the activity.

At the end of the session each student was asked to complete a satisfaction questionnaire. Some time during the following week they were expected to key in the data from their observation sheets and from their questionnaires into the spreadsheet templates that they down loaded from the course web site. They were asked to attach these completed spreadsheets to e-mails and post them back to the lecturer. No analysis of the satisfaction questionnaire is included in this paper as it was not intended to collect data regarding the learning experienced by the students but rather to give them an example of a typical questionnaire used in an authentic usability lab. The data collected is, therefore, not relevant to this paper.

Discussion of the Laboratory Session

The lab session clearly engaged the participants. This was undoubtedly reinforced by the fact that a mark was awarded for participating. The lecturer had worked through the tutorial carefully herself, and since she had no experience using this software or any other GIS software, and since she had no real problems achieving the expected results, she did not foresee that the students would uncover real interface design problems. It therefore came as a surprise that not only did some of the student groups have real problems, but also that at least one of these could clearly be identified as resulting from an interface design flaw.

The students could not complete the full tutorial in the time allowed and in many cases did not get beyond task four of seventeen tasks. This could not be ascribed to loafing as observation during the session and reviewing the video showed clearly that the students were active at all times and were anxious about lack of progress.

Two common problems that they encountered in the early tasks were:

- The software malfunctioned if data was entered into one of the forms in a sequence other than that the designer had allowed for.
- The required database could not be accessed if the data directory was not indicated correctly early on in the process. This

> particular error was not reported at the time when this information was entered or later when the data was supposed to be accessed leaving the student/user absolutely clueless as to why the expected results were not obtained.

Nevertheless, these problems do not fully explain the lack of progress by some students and this highlights an interesting research problem. What additional reasons are there for the enormous variance in the time it took students to complete the tasks despite the fact that they all had exactly the same instructions, prior exposure to the software, and supposed level of computer literacy? The method of capturing data regarding the actual actions of the 'end user' using hand written notes on the observation sheets was not adequate as insufficient detail was captured and the data was unreliable. The wide difference in progress seems to point firstly to a difference in ability to follow technical instructions and secondly a difference in ability to recover from setbacks that may be related to problem-solving ability. This aspect will be followed up in future research.

One of the most experienced groups, who themselves were floored by the first of these problems, took up the challenge and identified the set of events that had resulted in this particular error. The lecturer had to help the students recover from the second problem but this meant starting the tutorial again from the beginning.

The video recording of the session shows the difference in the experience of different groups. This ranges from clear frustration, despair and eventual 'giving up', to a sense of achievement and a desire to complete the tutorials. The team dynamics and work methods of different groups were also noticeable.

The Follow-up Lecture

Data Analysis

There was a break between the laboratory session and the follow-up lecture as Easter and a number of other public holidays intervened.

This allowed the lecturer to combine all the spreadsheets submitted (each student had submitted their own individual data the same spreadsheet layout). This was a simple operation as our students are accustomed to accessing lecture notes and other material from the module site and could easily obtain a copy of the skeleton spreadsheet, enter their own data, and e-mail the data back in the required format. A simple series of cut and paste operations allowed the data to be combined and this completed the task. Thus a realistic set of data was compiled.

Few of the Informatics students take Statistics courses and it is beyond the scope of the HCI course to teach statistical analysis techniques. None of the students had previously done quantitative research so the most elementary processes of checking, correcting and where necessary, discarding data were demonstrated using the data set which was obtained as described above. For example, some students had sent email twice and this had resulted in duplicate data in the data set. The duplicates were discarded. Some formatting needed to be done to achieve uniformity. All of these processes were very simple and did not compromise the data. Next the data obtained was analyzed in a very basic way using averages and graphs.

Very simple concepts such as standard deviation were discussed briefly in order to try to explain what statistical data can be considered meaningful. ANOVA was also explained in order to indicate how the responses of different categories of users could be analyzed. This part of the exercise demonstrated how data is collected and analyzed.

Excerpts of the video that was taken during the laboratory session were shown in the class simply to demonstrate the value of this type of recording and also the difficulties involved with analyzing videoed material. This provided the students with some amusement but there was not sufficient time to do any serious analysis and this section of the lecture did not justify the cost of making the recording. There was no useful audio recording as the general noise in the laboratory made individual comments inaudible. A commentary by the cameraman might have been useful but this was not an appropriate option as the person who did the camera recording had not been briefed as to what he should be looking out for and was not a lecturer or an HCI expert.

Review of the Usability Testing from the Research Point of View

The follow up lecture was also used to allow the students reflect on their own experience of usability testing as a means of software evaluation and to discuss how this could be improved. The satisfaction questionnaire was evaluated and the actual data collected was examined in order to highlight the weaknesses in the design of the questionnaire itself. Ideas were sought regarding other quantitative data that could have been collected so that the GIS interface design flaws and the actual processing problems (retrieval and manipulation of data from the database) that resulted could be identified more accurately. Since the students now had first hand experience of the weaknesses of the GIS software, we could discuss what interface features had caused problems and how these particular flaws had been identified.

The End User Experience

The final issue that was discussed was the problems that inexperienced end users have using software. The students now had personal, fresh and sometimes painful memories of the typical feelings of inadequacy that novice end users experience. They could recall that they assumed that they had 'caused' the problems rather than recognizing that these were largely embedded in the interface. Hence they were sensitized to some extent to the problems end users have when working with unfamiliar terminology.

Conclusion

The description of this constructive learning experience is intended to demonstrate how a fairly large number of different goals can be achieved simultaneously in three sessions each lasting two hours (the preliminary lecture on GIS, the lab session and the follow up lecture). Despite the fact that the goals of visual representation of data, complex HCI interfaces, usability testing and analysis of quantitative and qualitative data, and the problems of novice end users are independent, the laboratory session provided an authentic and fairly cohesive experience which allowed for genuine situated learning to take place.

The first of the lecture sessions, the introduction to visualization, GIS and the actual software gave a clear explanation of visualization, emphasized the 'real life' nature of the problem and provided a context for the subsequent work. The laboratory session allowed the students to actively participate as usability lab "researchers" and as "end users". The subsequent lecture allowed the experience to be assimilated and analyzed and also allowed additional aspects, such as data analysis and the discoveries made by some of the groups, to be explained to the entire class.

During these sessions the students were:

- Introduced to the idea of visualization of information
- Used a complex user interface
- Gained first hand experience of all aspects of usability testing including data collection and analysis
- Used an information system in a context where they were outside their comfort zones
- Were introduced to GIS

The lecturer had to do some planning but the load in terms of preparation and marking was not excessive.

This series of classes meets the general recommendations, described earlier, of various groups of Information Systems and Computer Science academics in that it goes beyond discussing the more obvious familiar interfaces and hence addresses the problem of a superficial understanding of HCI. It takes cognizance of some aspects of the interdisciplinary nature of HCI by focusing on the presentation of information in order to increase understanding, the design of interface tools and options to permit the human to instruct the computer easily, the methodologies for evaluation of software and human factors research. It uses a guest lecturer as recommended by Strong (1994). It is outcomes based and uses a constructive learning model. It provides students with a proper opportunity to reflect on the learning experience and to discuss it as a group and therefore specifically embraces a sociocultural approach. This series of lectures was not intended to give students an extensive knowledge of data visualization but this aspect will be extended in future during the first lecture. It is not possible to compare the details of the classes more specifically with theory as this is simply a description of a particular teaching scenario.

Although the teaching case described here was intended to contribute ideas to the educational rather than the research interests of Information Systems academics, it has uncovered some issues that could be explored further in a research project. Firstly, it highlights the difficulties the observer has in capturing sufficient detail of the actions of the 'end users' when simply recording notes on observation sheets. Secondly, it indicates very interesting differences in behaviour by the 'end users' in completing the task.

Notes

[1] Section D of the content of HCI in the ACM curriculum describes the Development process as including Design approaches, Implementation techniques, evaluation techniques and example systems and case studies (Hewett *et al.*, 1996).

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APPENDIX A

HCI lab session

Groups of three – NO EXCEPTIONS

Marks – out of 15 but in the following proportion
0 – did not attend
1 – did not participate satisfactorily
2 – satisfactory

Outcomes:

Once you have completed this exercise you will:

Have experienced some aspects of formal laboratory usability testing which will contribute to the discussion next week

Collected some data that I will combine with that of the other groups to demonstrate some basic non-statistical analysis in next week's class

Have personally seen how GIS software is used to assist visualizing data and allowing this data to be manipulated.

HCI Usability lab evaluation

Is controlled
Requires the subjects to do clearly defined tasks
Is done in a lab rather than in the field
The observer does NOT participate
Time taken is measured
Error frequency is recorded
Other aspects may also be noted

Student roles in the exercise

- One is a recorder
- He or she does not participate in the problem solving at all
- Uses the standard sheet to record times and errors
- One is the 'operator' who does mouse and keyboard input.
- One is the 'navigator'/assistant and tries to tell the operator what to do.

In your group you must decide who will fulfill each of the three roles. These roles will be changed (rotated) for the second part (Tutorial 2). The observer will become the operator, the navigator will be the observer and the operator will be the navigator.

Deliverables:

Although the lab evaluation and data collection will be done here tonight, the final typed data must be handed in, in electronic form (e-mail or diskette) by end of day, 5 May. The layouts will be on WebCT by the end of day Tuesday 15 April. **Please use those layouts only.**

Three completed and typed satisfaction questionnaires in electronic format using your student number as **file name** e.g. S1234567

A completed and typed observation record – share the work between the three team members in excel format, combine into a single file and submit using your group number as **file name** e.g. Group1.

Make sure the names of the students in the group are filled in on the electronic form.

Author's Contact Details

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