Technology - Empowering the Educational Researcher through Remote Observation

Conference or Workshop Item

1. Introduction

Within the domain of human-computer interaction (HCI), observation studies have often been employed to assist in improving the design of software, typically as part of usability tests. However, educational researchers' use of observation studies has tended to be more concerned with obtaining rich data on students' computer interactions in order to understand how or what students are learning (e.g. Berry, Graham and Smith, 2006; San Diego, Aczel and Hodgson, 2006).

Three broad methods for human-computer observations have been used in particular. These are observations in a user-lab, on-site or through remote data logging (Holzinger, 2005). In the user-lab situation, the participants are invited to a lab where the participants interact with the software and can be observed by the researcher. The on-site observation is similar except that the researcher goes to the participants and observes them whilst they work on their computers. In the remote data-logging observation, special software is loaded onto the participants' computers to record keyboard and mouse clicks for later analysis.

With the increased use of online technologies for learning, in homes, at workplaces and on the move, each of these three methods has advantages and limitations. A fourth method is presented as an alternative which uses broadband internet technologies. This fourth method employs web conferencing facilities to observe, at a distance, participants interacting with their computer. In this paper, this method is termed "web-conferencing remote observation". Two proof-of-concept studies are reported here, the first using Windows Messenger® web conferencing facility and the other Netviewer®, to explore the implications of this kind of data collection method for researching the use of software in education.

2. HCI Observation Methods

The three HCI observation methods are outlined below. As with most observation methods, there is a risk that the students may be susceptible to the Hawthorne effect (see Lethbridge, Sim and Singer, 2005), that is, work harder or better because they are being observed. It is also worth noting that the choice of method is not dependent simply on the research question being investigated but also on the resources available, the skills of the researchers and the population characteristics (Hammersley and Atkinson, 1995; Sapsford, 1999).

2.1 User-Lab Observation

In a typical user-lab observation, the participants are invited to a lab in which they can be audio and video recorded while they use whatever software is under scrutiny. Further, the contents of the computer screen can be captured, either using hardware or a screen capture utility installed on the computer. Think-aloud protocols (Ericsson and Simon, 1984) may also be used to get further insights into how the participant is learning. With the advent of digital video, new opportunities have been opened up for capturing, coordinating and analysing what learners say, do, see and write when at a computer (San Diego *et al*, 2006). For example, eye-tracking devices allow researchers to identify where exactly on the screen learners are looking at any moment in time. Moreover, Tablet PCs can be used to capture writing and sketching over time.

A major advantage of the user-lab method is that sophisticated but bulky equipment, such as eye-tracking devices, can be used; and data capture configurations that take a long time to set up can be left in place, allowing many participants to be recorded in the same way.

However, it is possible that bringing participants into labs bristling with recording devices may make participants more conscience of the fact of being recorded, and so less likely to engage with the software in a natural way. Jordan and Henderson (1995) have noted, for example, that people tend to be less comfortable when there is someone controlling the camera. It could also be argued that the user-lab method makes the power balance between researchers and participants very unequal, since the researchers have more control over the research environment. Further, unfamiliar keyboards, mice, screen colours, resolutions, and lighting conditions might contribute to participants' discomfort, and perhaps increase their anxiety in an artificial environment (Bessiere, Ceaparu, Lazar, Robinson and Shneiderman, 2002). This anxiety has the potential to affect the quality of the data.

On the practical side, unless participants are on a campus and can be easily recruited, using the user-lab method with a large sample can incur higher costs in getting the participants to the lab. There might also be logistical problems in booking the user-labs if there are a limited number of computer stations available. The costs, logistics of booking rooms, and observational time could perhaps limit the sample size of the study. This probably would mean this method would have to rely on a small number of participants and might therefore be better suited to a mostly qualitative data analysis approach.

2.2 On-Site Observation

An alternative approach is to observe participants in their natural environment (Guba and Lincoln, 1981). In this method, the researcher arranges a time with the participants and then goes to their place of work or home and observes them as they interact with the software. While some of the methodological issues described above also apply here – such as discomfort at being videoed – participants are using their own equipment and the power balance between researcher and participants are less unequal. Furthermore, the researcher is likely to be able to get a more holistic view of the participants studying environment, which may aid in the explanation of any data.

However, on-site observation could be potential be construed as a greater intrusion into the privacy of the participant than a lab visit and the field work might prove a distraction to other people if it is a shared environment particularly if a think-aloud protocol is employed.

The costs related to this type of study may be high if the researcher has to travel far and it setting up equipment may also be time consuming. Again, as with the user-lab observation, on-site observation is arguably suited to a smaller number of participants using a qualitative data analysis approach.

2.3 Data Logging Remote Observation

The data-logging remote observation method strives to keep the advantages of the naturalistic observation without requiring the researcher to travel. In this method, data-logging software is loaded unto the participants' computers from which mouse-clicks and keyboard entries are recorded. For example, the AESOP (*A*n *E*lectronic *S*tudent *O*bservatory *P*roject) at the Open University (Thomas and Paine, 2002) has used this method to observe distance-learning students doing computer programming in their usual setting. The data for the AESOP project depended upon participants installing logging software and returning the recordings in a text file via email. This places a burden upon the students and relies upon their conscientiousness in emailing the recordings. The data-logging remote observation method provides the most flexible environment for the student as they are not constrained by the researcher's availability.

The power balance in this method is mostly on the participants' side, which gives them some extent of autonomy in their environment. Some participants may feel less discomfort with this observation as there is no camera being pointed at them but on the other hand some participants might feel as everything on the computer is being recorded and therefore they are being spied upon continuously. However, the method lacks any richer data such as the video and audio data. The think-aloud protocol cannot be used, although presumably after the participants' session, interviews can be used to elicit these types of data to some extent.

The method allows a large number of participants to be used and so is well suited to both quantitative and qualitative designs. However, the returning of the data is dependent on the participant and if the participant is not conscientious in returning the data there maybe missing data sets. This might be problematic for experimental designs. Nevertheless, unlike in the user-lab or on-site observation methods in which observation time is constrained, the data logging remote observation method lends itself to longitudinal data collection.

3. Web-Conferencing Remote Observation

Web-conferencing remote observation tries to combine most of the positives of the previous methods discussed. As it is a type of remote observation, it is particularly suited for participants working in their natural environments. In web-conferencing remote observation, participants interacting with software are observed via the internet by employing webcams and application-sharing facilities which are usually bundled into web-conferencing software.

The web-conferencing remote observation process lends itself to both a qualitative and quantitative data collection. Firstly, this method can collect both video and voice data and provide a richer analysis than the data-logging remote observation. Secondly, much higher numbers of students are possible compared with the on-site and user-lab observation. Moreover, quasi-experimental designs can be employed using pre and post-tests which may be constructed on the web. Participants can enter the answers online and these can be sent directly to the researcher. This helps in getting an electronic copy of the data which reduces the need for transcribing or inputting. Moreover, unlike the data-logging remote observation method, there is no dependence on participants' conscientiousness in emailing the data. However, any additional workings that participants may do, such as scribble or sketch on pieces of paper may be lost unless the researcher asks the participants to use sketching software which they can application share as well.

This remote observation procedure is particularly suited to the new type of students that is distance and e-learners as makes it difficult to invite them to a user-lab. This remote observation allows the researcher to observe participants in their naturalistic environment and probably aid in understanding how the participants' external environment influences their learning. The participants have the comfort of using their own equipment without creating any anxiety in operating new equipment. As the participants are in their environment they can easily find or locate familiar materials such as pen/paper or calculators. This may be a disadvantage if the study calls for the participant to only use materials provided for them. Even if that was not the case, since the researchers are able to see the participants' desk space and what they are doing on their screen with respect to the application programme, the researcher can instruct or stop them from doing something that is not in accordance with the study.

Also, as the participants are in their own environment there is no overwhelming issue of power relations balance (Hammersley and Atkinson, 1995), that is the research environment is not completely controlled by the researcher as it would be in an user-lab

situation. Further, this remote observation method allows researchers, with minimal extra cost, to extend their population or sample group to participants in different parts of the country or in different parts of the world. However, there may still be limitations to this as some countries particularly less developing countries may not have the required broadband speed. Also, participants who are disabled or have mobility issues may be more willing to take part in these types of studies as they can use their own machines configured for their own particular needs, and hence the researcher can have access to a wider sample population of this type.

There are fewer problems with logistics since the researchers can use their own personal computer and also the only arrangement is that for a virtual meeting time with the participant. This means that a larger participant sample can be used but perhaps not to the same extent as that of the data-logging remote observation.

Further, the researcher effect is also minimized. The researcher has also has some freedom in being to react such as facial expression to what the participants are saying without adversely affecting what the participant is doing, as participants are not likely to see them through the webcam. Further, the researchers can talk or make notes without making the participant anxious about what is being written about them, as they are unlikely to see the actions of the researcher.

4. Practical Setup

In web-conferencing remote observation, there are basic requirements for the researcher and the student for the study to be conducted. These requirements are presented in Table 1. Most web-conferencing software allow the researcher and the participants to have a voice/video conversation, application sharing and an instant messenger (IM) facility. Using a voice/video conversation through a web-conferencing facility permits the researcher to instruct the participants and allow follow-up interviews after the session. Further, since the video is streamed through a webcam, the webcam can be recorded using screen capture software to create a video. Also, the voice-conversation can be recorded through an audio-recording device.

Through application-sharing, the software on the researcher's computer can be shared to the participant through the internet, and control of the software can be undertaken by the participant providing permissions are given. This means that for most software, even if the participants do not have it loaded on their computers, they can still use software that is loaded on the researcher's computer. Further, whatever the participants do on their computer with respect to that application, the researcher can view it on his/her computer and hence can employ screen-capture software to also create a video of participants' interactions. The screen capture software although it can record mouse clicks and keyboard entry on the researcher's computer these are not recorded when there is application-sharing as all the mouse and key-board entries are occurring from the participants' computers. However, it is possible to record a mouse trail, that is follow where the mouse is moving from or to.

The remote-observation method assumes that the researcher and the participant will be using their own computers and would have administrative privileges on their computer. This is necessary as software for the applications has to be loaded. Further to capture, the environments in which the participants are doing the computer-interaction, participants are encouraged to position their webcams to capture their general desk/working area (see Figure 1).

4.1 Ethical Issues

Researchers however must ensure the participants that they are meeting certain ethical conditions in order to ascertain remote desktop sharing security. For example, anonymising real name in any written documents (anonymity); ensuring that no recordings will be used for any other purpose other than to carry out this study (purpose); data not making available to third-parties (confidentiality); during desktop sharing, participants will have the control to approve any applications running on their computer (security); data stored in the researchers' computers are password protected and back-up copies are stored safely (data protection). Additionally participants should be given the right to ask any questions about the nature of the study and the methods will be used, and given the option to withdraw at any time they wish to.

The editing of video image and sound can offer further options for anonymising participants' identity. Participants can be offered an option to show their images and voice either altered or unaltered for purposes e.g. research presentations or academic conferences. This entails video and audio data of participants who consented can be used for presentations whilst data collected from others can still be presented in textual forms. Some researchers may place video data over the internet to allow other researchers to access and view. If data are made available to others, these data should be accompanied with further ethical conditions on which users should agree before access to videos can be obtained.

5. Proof of Concept Studies

5.1 Web-Conferencing Remote Observation via Windows Messenger

This study employed the use of remote observation on understanding how students learn with different mathematical calculators/software which is further discussed in Hosein, Aczel, Clow and Richardson (2007). This study investigated if students learn/ interacted differently with three types of calculators: black-box, white-box and grey-box when learned expected values. In this method, Windows Messenger acted as both the voice/video conversation and the application sharing software. To enable screen capture of both the application sharing and that of the video/voice conversation two computers were used (see Figure 2). Technically, one computer can be used if the screen is large enough to hold both windows (application sharing and the voice/video conversation) to a satisfactory size and the RAM of the computer can run all these processes. As Windows Messenger was used, three Windows Messenger identities were created. The first identity was created for voice/video conversation, the second for the application sharing and the third identity for the participant. The participant's identity was used to allow the participant to enter into the remote observation exercise. The participant's name was usually set before hand.

In this study, think-aloud protocol (Ericsson and Simon, 1984) was also used together with a quasi-experimental design requiring pre and post-tests (Campbell and Stanley, 1963). The pre-test was sent as web-forms from which data collected was already in a digital format. The post-test was created as a Visual Basic form which was attached to the application, although this could have been a web-form as well.

5.2 Remote Observation via Netviewer

Netviewer was employed to be used to study how participants used OpenLearn to study. OpenLearn is a project where e-learning courses are available online for free and

students use these for informal learning.

As Netviewer is an integrated package, both the voice/video conversation and the application sharing processes shared one window, thus requiring only one computer. The voice/video conversation was slightly different to that of the Windows Messenger, as it did not allow synchronous voice/video conversation. A queuing system for the voice/video conversation is used in Netviewer where the participant and the researcher each had to request when they wished to talk. This study observed the students through the webcam as well as employed the think-aloud protocol.

A comparison of Netviewer and Windows Messenger for remote observation is presented in Table 2. Windows messenger is the cheap alternative as it is readily available on all personal computers (PC) that has Windows XP®. One of the advantages of Windows Messenger over Netviewer is that it allows synchronous voice/video conversation. This means that overlapping conversatons between the researcher and the participant is allowed. As Netviewer only allows one person to talk at a time, some type of protocol has to be set up to decide when or who wants to talk. This may be contradictory to how the think-aloud protocol works as the participants have to make a conscious effort to make sure the talk button is on before they can voice their thoughts.

However, Netviewer has the advantage of being an integrated package, which means there is less of an issue in trying to synchronize the videos of the software application and the webcam as they are all hosted within Netviewer. There are other packages such as E/pop, which provides the integration of Netviewer and also the synchronous voice/video conversation but these software are quite expensive. However, one of the advantages of E/pop is that there may be multiple synchronous conversations and this may prove useful in observing how distance-learning students may collaborate perhaps in or holding virtual focus group discussions not necessarily with anything to do with observing computer interactions.

5.3 Consent Form

As these studies were meant as a proof of concept, the study considered that researchers and participants would not meet physically. This meant that the signing of consent forms for the authorization of video/audio recording was a practical issue that needed consideration. Therefore, signed consent forms were not considered a viable option unless these forms were sent via to the participants through email and then asked for them to sign and mail or faxed these back. The practicality of using participants possibly in different countries would make mailing a time-consuming procedure and also a cost-burden on the participant. The cost-burden on the participant would also feature in the faxing method. Further, considering that the participants would be students, access to a fax machine would, for the most part, not be convenient. As such, the solution was that participants could be emailed a link to a web-form where they could input their names, their email addresses and click submit to indicate that they have given consent. When they have clicked agreed, an email message could be sent to them to indicate what terms of the consent they have agreed to. To cover all bases, during the initial starting of the remote observation session, the participant could be told once again the issues surrounding their consent either through instant messaging or voice/video conversation where they can orally agree.

5.4 Data Quality

One of the main concerns, for this remote observation method, was whether useable or good quality of data could be observed. The webcam video data was not of the highest quality, that is, it is not similar in quality to a video recorder as the picture had a lower

resolution and appeared grainier. Also, depending on the internet connection there was skipping in the video. However, as this data was only being used to get a sense of the environment and what the participant was doing (Jordan and Henderson, 1995), the webcam data was considered sufficient. One added problem was that unlike traditional video data recording, this method was dependent on the participant fixing the webcam and this meant there was variability in what the researcher could see.

With screen capture software, the quality of the video data of the participants interacting with the software was good. However, because the application sharing is dependent on the internet connection and the computer's memory - as the computer is also using its memory resources for recording the screen - the application ran slower than it would normally do. There were also recorded sudden jumps when using the mouse and words quickly appearing a few milliseconds after they are typed.

The audio quality was good as that of Voice Over IP (VOIP), although again it depended on the internet connection as sometimes skipping occurred or echoing of words. A problem with the data collected through remote observation was the synchronizing of the video(s) and audio files. If the webcam and application were captured on separate files then these prove difficult to synchronize exactly as skipping of the webcam has to be taken into account. However, the two videos could be near synchronized without any adverse effects in observing what the participants were doing, particularly, when this data was triangulated with data from a think-aloud protocol. This is not a problem if both the application and the webcam are screen captured at the same time on a large screen. There was the other complication of also synchronizing the videos together with the audio, particularly when there was a long audio conversation before the videoing of the application has started. Also, there may be skipping in both the audio and video streams because of the internet connection. This perhaps could be circumvented by using a screen-capture utility which also allows the recording of both audio in and out.

5.5 Participants' perspectives on remote observation

Participants in this study found the camera to be somewhat non-intrusive which is similar to other video recording studies. Comments with respect to the webcam included:

> "*I just completely forgot about this. I'm just looking at the application sharing, I just don't look at windows messenger*".
>
> "*Webcam ….. Actually I forgot about it*".
>
> "*Using the webcam doesn't make a difference to me*".

This is perhaps because the webcam was part of their environment already and hence they were not conscious about it (Jordan and Henderson, 1995). Further, since the voice/video conversation window was often minimized this meant there was not a constant reminder that the participant was being recorded. This, however, does not mean the Hawthorne effect is minimized particularly when using such strategies as the think-aloud protocol as participants were reminded that their thinking processes must be spoken and they found this an un-natural interaction in their learning (Holzinger, 2005). For example:

> *"It's alright. Sometimes when I'm thinking … you say I need to talk aloud …sometimes I just want to keep silent.*'

One participant indicated that perhaps using the remote observation process together with the think-aloud protocol might be a problem when in a work/office environment as it "*might disturb friends and colleagues*". This is not an issue in a user-lab environment but

may be an issue in an on-site observation.

6. Final Remarks

6.1 Reflection on Participants

In both studies, participants were recruited using emails through a known list of participants. This works where students in a particular course or faculty are being investigated and where students' contact details are easily obtainable. If however, participants are unknown to the researcher and the research is not tied to a particular course then perhaps users can be obtained through the internet by either posting messages in forums or popular websites (e.g. Clough, 2005) . This method is currently being tested for finding useful remote observation participants.

6.2 Reflection on Web-Conferencing Remote Observation

For both studies, web-conferencing remote observation was found to provide added flexibility in deciding where and when to carry out the research. In addition, the method offers further possibilities for conducting quantitative and qualitative research. The synchronization of the data required some effort, however, the richness of the data produced and the range of participants that can be included were major advantages.

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