Video Analysis of Learners' Interactions with the Expert: Using Mobile Devices as Mediating Tools for Learning at a Museum

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Abstract: This paper examines the interaction and communication of students with an expert at a museum using mobile devices as mediating tools for learning. In this study, the main focus of analysis using "focus shift and breakdown" is selected for detailed video-based interaction analysis. The five design factors for mobile learning are developed based on the analytic categories of five interesting situations from the video-recorded data. These design factors are (a) ***C**aptur*ing learning experiences, (b) ***Act***ing in the physical world, (c) ***I**nteract*ing with the expert, (d) ***C**ollaborat*ing with learners, and (e) ***A**ccess*ing symbolic resources on the Internet. The purpose of building these design guidelines is to help educators and teachers design their mobile learning activities.

Introduction

The main purpose of this paper is to examine the communications and interactions of students with an expert at a museum using mobile devices as mediating tools to support the students' learning. A detailed video-based interaction analysis was conducted based on the selected video-recorded data. This video analysis may assist in understanding how learners interact with an expert at a museum using a mobile device as a mediating tool. This research study is part of the Australian Research Council (ARC) Linkage project, titled "Designing for Mobile Learning in a Technology Museum", with the Powerhouse Museum (PHM) as the industry partner. The study adopts the Learning-By-Design (LBD) concept (Kolodner et al., 2003), and the learners are required to perform an exhibition design as part of their learning activities. The entire research project involves a thorough investigation on the effects of mobile devices on students' learning. However, this paper only reports the outcome of the video analysis of the learners' interactions with the expert at the museum using "focus shift and breakdown" analysis.

Learning-By-Design (LBD)

Kolodner et al. (2003) state that LBD emphasizes learning through hands-on design activities in which learners engage collaboratively in design activities and reflect on their experiences. LBD is a project-based inquiry approach rooted in *case-based reasoning (CBR)* and *problem-based learning (PBL)*. *CBR*, a constructivist model of learning, "refers to reasoning based on previous experiences (cases)", whereas *PBL* is a cognitive-apprentice-style approach (Barrows, 1985; Krajcik & Blumenfeld, 2006) to educational practice such that "students learn by solving real-world problems and reflecting on their experiences" (Kolodner et al., 2003, p.501). An interesting finding from Kolodner et al. (2003) shows that LBD brings normal-achieving students to a level of capability usually found only among gifted students. It seems the LBD activities engage students to perform better because LBD gives students the opportunity to apply what they perceived and be appreciated for it. "Learning from design activities affords rich opportunities for learning." (Puntambekar & Kolodner, 1998, p.35). Through this process of designing and manipulating the artefacts, individuals can construct and generate rich meaning (Piaget, 1954; Perkins, 1986). In this study, the learners' participation in their exhibition designs, using the concept of LBD with mobile devices as mediating tools, helped them think about their own learning throughout the whole design process.

Video and Interaction Analysis

Video analysis is a valuable analytic tool for studying learning activities in the real world. While video-based analysis is highly time-consuming, the video data provide a rich and high level of complexity of interaction such that the analysis is not only useful in terms of conversation, but also in terms of human interaction. *Interaction analysis* has been intensively used to analyse video data, as it allows researchers to analyse both conversations and interactions of individuals with other participants as well as with the artefacts in a physical environment. Video-based interaction analysis is a powerful tool to investigate human activity, particularly in complex, technology-mediated work settings and learning environments (Jordan and Henderson, 1995).

Foci of Analysis

Jordan and Henderson (1995) suggest the use of *foci of analysis* to analyse video records based on their many years of extensive ethnographic studies on the relationships between people and computers systems. Bøkder (1996) outlines a technique for the mapping of use situations (1) that have been recorded on videotape using "focus shift and breakdowns" to analyse human-computer interaction. Bøkder (1996) shows how *"focus shifts and breakdowns"* are instrumental in analysing human-computer interaction, and she outlines a technique for

the mapping of use situations that have been recorded on videotape. She further explains that *breakdowns* "related to the use process occur when work is interrupted by something", and *focus shifts* are "a change of focus or object of the actions or activity that is more deliberate than those caused by breakdowns" (p. 150).

Participants

There were three participating groups: the MO-bile group (2), the Online group (2), and the Control group (2) involved voluntarily in this research project. Only the students in the MO-bile group had the opportunity to visit the museum using mobile devices (Tablet PCs) as mediating tools for learning. The other two groups used the online resources for their learning activities. Each group has six to seven students (all in Year 8) coming from different schools (private, local and selected government schools), with a mix of boys and girls. This paper focuses its investigation on the MO-bile group and the interaction of this group with the expert at the museum.

Method and Main Theme of Video-Based Interaction Analysis

The aim of this research is to understand how mobile devices affect learners; it emphasizes not only learners' learning but also learners' communication in an informal learning environment. The analysis of the entire research study includes a quasi-experimental study and an embedded single-case study. However, this paper only presents the study of the video-based analysis of the students interacting with the expert in a co-located learning environment in which they used mobile devices as their mediating tools for learning.

Students in the MO-bile group had an hour-long discussion with the expert (curator) about their final exhibition designs. The students' final exhibition designs were captured on the Tablet PCs, and each student took his or her Tablet PC to discuss their own design with the expert at the PHM. No pre-set meeting structure was scheduled, and it was entirely up to the discretion of the expert to determine how this learning activity was to be delivered. The expert had all sorts of freedom to carry out the discussions and give advice to each student about his or her design at the exhibition space in "Cyberworlds", the location where all 33 museum exhibits were selected and given to the students to help them design their exhibitions. Moreover, all of the students' interactions with the expert using the Tablet PCs at the PHM ("Cyberworlds") were video-recorded.

In working on the video analysis for this study, a combination of ethnography and interaction analysis methods was adopted. In the ethnographic context, some brief concurrent field notes were collected while videotaping so that some interesting instances could be notified and used for closer examination later.

As mentioned previously, a detailed analysis of an hour of video-recorded data is a complex matter. Instead of frame-by-frame transcription of an hour of video data (about the interaction of students with the expert, including verbal and non-verbal behaviours), a fragment of five interesting situations with a total of five minutes and twenty-five seconds in length was selected. The researcher viewed this fragment of video data over ten times in order to obtain a deep understanding of the phenomena related to the use of mobile devices by learners in an informal learning environment. This fragment of interesting sequences was selected for closer inspection through successive approximations. The analysis then proceeded with an identification according to the relevant analytic categories and careful transcription (the data from the videotapes was transcribed frame-by-frame in both verbal and non-verbal transcriptions) of sequences of activity related to a particular interest.

Accordingly, the relevant analytic categories were identified based on five interesting situations: (a) ***C****apturi*ng learning experiences (5), (b) ***A****cti*ng in the physical world, (c) ***I****nteracti*ng with the expert, (d) ***C****ollaborati*ng with learners, and (e) ***A****ccessi*ng symbolic resources on the Internet. Five snapshots of five frames (in the format of 2D photos) representing five situations that were extracted from the video-recorded data are mapped into these five categories are shown in the first column of Table 1. The last column provides a detailed note explaining how the participants interacted with the expert. The focus of analysis of designing for mobile learning in an informal learning environment was based on these five categories. The analysis focused on the students' non-verbal behaviour rather than their verbal conversation.

Result and Analysis using Focus shifts and Breakdowns

The main focus of analysis in this study is the "focus shifts and breakdowns" of the learning tasks and the use situations. In this study, the goal of using "focus shifts and breakdowns" to analyse of the mobile learning activities at the PHM intended to provide a deeper understanding of how the learners used the mobile devices as mediating tools for learning in an informal learning environment. This analysis was based on the selected fragment of video-recorded data emphasizing the MO-bile group students using mobile devices to interact with the expert at the PHM. The intention of this study is not to investigate the low-level interaction of the participants that involved detailed interaction analysis (such as gesture and facial expression) rather, it aims at the focus shifts of different use situations. The interesting situations mapped and analysed according to the "focus shifts and breakdowns" were suggested by Bødker (Bødker, 1996; Suchman & Trigg, 1991).

From an hour of video-recorded data, a fragment of five interesting situations (i.e. a total of five minutes and twenty-five seconds) of participants using their mobile devices at the museum was selected for detailed analysis, and then the actions of use situations were mapped. The focus shifts occurred from one action

of activities to another (i.e. from one "use situation" to another). The actions of the activities/situations can be categorised according to the five key ingredients for designing mobile learning in an informal learning environment.

Table 1 shows the *"focus shifts and breakdowns"* analysis of this study. Initially, the focus was on the action of situations concerning the student's final exhibition design. The student's exhibition design was ***Capture***d in the mobile device (Tablet PC) as was Student MG3's interaction with the curator about her design with the help of this device [1]. However, as soon as Student MG3 realized that she had a query about a museum exhibit related to her design, she walked towards the other side of the exhibition space and the curator followed her, carrying her mobile device with him to the other end of the exhibition space. The focus shifted to another situation: Student MG3 and the curator both ***Act***ed in the physical world to clarify the queries by investigating the physical artefacts – museum exhibits using the mobile device [2]. While they were discussing the matter, another situation occurred. Another student, Student MG1, found something interesting and wanted to discuss it with Student MG3. She went to Student MG3 with her mobile device, and both students ***Collaborate***d with the help of the device [3]. After the students finished the collaboration, Student MG1 walked away with her mobile device. She realised that she needed more information about the museum exhibits, and then the focus shifted to another situation, as Student MG1 immediately ***Access***ed the symbolic resources with her mobile device [4]. After Student MG1 finished her searching, she identified some queries that she wanted to put to the curator, so she went back to him. Another set of situations occurred, wherein Student MG1 and Student MG3 ***Interact***ed with the expert at the PHM with the help of their mobile devices [5].

Table 1 shows the details of this analysis with five 2D pictures representing the instances. The analysis of "focus shifts and breakdowns" with the five snapshots of five delineated photos is demonstrated in column 1 of Table 1. In column 2 is the mapping consisted of listing in one dimension – the action of situations/activities (i.e. ***C***apture, ***A***ct, ***I***nteract, ***C***ollaborate, and ***A***ccess) – that the participants focused on during the session (with reference to a snapshot for demonstration). Column 3 of the table shows the narrative of the situation, supplemented with the detailed explanation emphasizing their non-verbal behaviour (Bødker, 1996).

Discussion

The design artefact of the exhibition design provides a rich learning environment for students. With the mobile device as a mediating tool that captured the students' exhibition designs, the students had the opportunity to explore and generate rich meanings, as they could easily *act* in the physical world (for example, at a museum), together with their own design artefact.

In this study, after students finished their final exhibition designs, they re-visited the museum where they were required to carry out a series of mobile learning activities at the museum. There, each student in the MO-bile group was provided with a Tablet PC, and all the students' final exhibition designs were captured inside this device. Students could retrieve their own exhibition design at the PHM while discussing and interacting with the expert. They were also allowed to compare and view the other students' exhibition designs. Furthermore, students had the opportunity to act in the physical world (at the museum), collaborate with their peers and interact with the expert regarding their exhibition designs. Students could also annotate and change their exhibition designs accordingly, and their new designs could be re-captured in their mobile devices. Thus, the Tablet PCs helped the students learn about the exhibits while touring at the museum.

The video data included a recording of Student MG3 walking spontaneously towards the other side of the exhibition space to further explore her queries about the museum exhibits of her exhibition design, and the expert followed her immediately, carrying along her mobile devices. This action, which was not planned, clearly indicated that the aspect of mobility provided by the mobile devices enabled the learners to act freely in an informal learning environment.

The important challenge of using mobile devices is to allow learners to be engaged in an activity that is mediated by the device. However, that action of activity does not hinder their experiences or force their attention onto the device itself, taking away their attention from the activity that should be supported (Vavoula et al., 2005). Some mobile learning projects that occurred with this problem are described below. The first example was the pilot trial for multimedia guides at the Tate Modern Museum in 2002 and 2003. This project did not function entirely as planned due to technical problems and the complicated interface of the PDAs that confused the visitors during their visits to the gallery/museum. Subsequent examples of the related problem were also found in studies of the Exploratorium (Fleck et al., 2002). To possibly avoid this problem, in this research study, the students' final exhibition designs were captured in the Tablet PCs, and these devices were used as mediating tools to support their learning of the specific topic (i.e. "History of Computers"). Students spent weeks designing their exhibitions. They met the expert online and they all had a good impression of him. Therefore, when the students came to the museum, they were keen to meet the expert and discuss their designs further with him. This provided the opportunity for the students to construct and generate rich meanings (Piaget, 1954; Perkins, 1986; Puntambekar & Kolodner, 1998) about the museum exhibits by interacting with the expert, taking along their Tablet PCs at the museum. The mobile devices, using this setting in the museum context, can

Table 1: Understanding focus shifts and breakdowns using mobile device as a mediating tool at the Powerhouse Museum. [Source: Mann, 2010].

	C	A	I	C	A	Details
	1					**Exhibition design file is *Captured* in the mobile device** *C*: Looked attentively at the exhibition design displayed on the Tablet PC. *MG3*: Took over the stylus pen and used this pen to show the curator how to move around the exhibition room and clicked on the exhibition object to retrieve the text description of the museum object from the design file through the Tablet PC. *MG1*: Curator watched attentively how Student MG3 showed him to manipulate this design file.
		2				**Student and expert *Act* in the PHM with the help of the mobile device** (Student MG3 tried to walk towards the other side to find out the museum exhibit that she did not understand, and curator followed her while still holding her Tablet PC) *MG3*: Looked at the museum exhibit while waiting for curator to come over and then showed the curator the museum exhibit that she did not understand. *C*: Curator bent down a little bit to see what the museum exhibit was that Student MG3 did not understand (at the exhibit object of the conductor). *C*: Curator used finger and pointed to the museum exhibit and explained to Student MG3 how it worked and then turned back, facing Student MG3. *MG3*: Looked attentively while curator was trying to explain to her.
				3		**Students *Collaborate* with each other using the mobile device** *MG1*: Trying to walk towards Student MG3, carrying along with her Tablet PC, and she intended to show Student MG3 some interesting information on her Tablet PC. *MG3*: Turned her head to the right to meet Student MG1. *MG1*: Held up the Tablet PC and showed Student MG3 some interesting things, and she also collaborated with Student MG3 for a few seconds with a laugh before she walked away.
					4	**Student *Accesses* extra symbolic resources using the mobile device** (At the back, curator still holding the Tablet PC and had a further discussion with Student MG3) Student MG1 was still inside the screen, and she was accessing the web resources using her Tablet PC for over 10 sec.
			5			**Students *Interact* with the expert (curator) in Powerhouse Museum using mobile device as a mediating tool** *MG1*: Joined the conversation with the curator, and she also wanted to talk and show her information to the curator. *MG1*: Held up her Tablet PC and then looked at her design on the screen, and she intended to show her design to the curator. Curator also seemed interested to have a look. *MG3*: Continued the conversation with the curator. *MG1*: Curator listened attentively to what Student MG3 said, and Student MG1 also was trying to use the stylus pen to draw on the screen of the Tablet PC.

Note: Numbers in orange color under the middle column of **C A I C A** [for example, 1,2,3,4,5] index the action of situations mainly focused on for the reference in the discussion; boldface and underline type shown in the last column are used to indicate a focus shift between use situations.
MG3: is Student MG3, *C*: is the expert at the PHM (i.e. the curator), and *MG1*: is Student MG1

act as mediating tools to assist students to engage in learning (to *act* in the physical world at the museum, to *interact* with the expert and to *collaborate* with their peers), but not to distract them away from the learning activity.

While there are many benefits of using the video-based interaction analysis to investigate the effects on learners with mobile devices, this analysis also has some drawbacks. Only a small number of students (in the MO-bile group) were involved in this detailed video analysis; therefore, the scalability may affect the generalisation. Moreover, there are other limitations in this video analysis because only one researcher and one transcription professional were involved in conducting the entire analysis. It would be useful to involve a local expert, such as the person on the tape, and have him or her attend the video review sessions. However, this was not possible, and it has not been done.

Conclusion

In this study, the learning activity of the exhibition design allowed the students to put real objects into practice (i.e. making use of the 2D museum exhibit pictures for students to design an exhibition). This exhibition design learning activity was further implemented in the informal learning settings with the help of the mobile devices.

In this study, the exhibition design (with the LBD concept) intended to create a rich learning environment for the students and make use of this learning activity with mobile devices to serve as mediating tools for student learning in an informal learning environment.

A good mobile learning design does not merely implement a set of mobile learning activities using mobile devices. Its success depends highly on whether its context can be set in a rich learning environment and particularly on whether the mobile devices can enhance the learners' ability to ***A**ct* in the physical world, ***I**nteract* with the expert, ***C**ollaborate* with learners, and be able to ***A**ccess* symbolic resources wirelessly through the Internet (Mann & Reimann, 2007; Mann, 2008). The emphasis of this study is not so much on ***C**apturing* learners' experiences using mobile devices; rather emphasis is on the features of mobility of the device. The mobility provided by the mobile devices gives learners opportunities to *act* at the museum, *interact* with the expert, *collaborate* with peers and *access* extra Internet information on a specific topic with reference to their *captured* design artefacts (i.e. students' final exhibition design files). These five key ingredients were identified based on the detailed video-based interaction analysis. Further comparison of these five design factors with the other mobile learning exemplars were performed but this information has not been included in this paper.

As discussed above, the selection of video-based interaction analysis aims at using the theoretical concept of "focus shifts and breakdowns" and is driven by the design issue. The development of these five design factors is not focused on designing a mobile device itself, because that would require a deep level of understanding of the low-level interaction of participants (for example, gesture and facial expression). Rather, these design guidelines are based on the five design factors with five resource elements: device, expert, learners, exhibits and symbolic resources (on the Internet). The purpose of building these design guidelines is to help teachers and educators when designing their daily mobile learning activities for their students.

Endnotes

(1) Use situations – a specific term used by Bøkder (1996) in analysing and tracing the actual focus shifts in specific use situations. She outlines a technique for mapping use situations based on the video data.

(2) MO-bile group has mobile and online settings, Online group has only the online setting, Control group has no treatment

(3) "*Capturing learning experiences*" is the semantic shortcut for "Capturing the information of the students' activities (through the use of mobile devices) that contribute to their learning experiences".

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