SUPPORT STUDENTS' OUTDOOR EDUCATIONAL ACTIVITIES WITH HANDHELD TECHNOLOGY

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Abstract

Handhelds and smart phones have become more commonly available. This paper describes an inquiry involving the use of handheld devices with a group of school students engaged in a fieldtrip. Throughout the six-day trip to Northern Thailand, students engaged in variety of activities, with the aim of acquiring some of the key concepts and skills of the Year 12 Geography. The student used handhelds for data collection, collaboration and reflection. A variety of qualitative data was gathered. Analysis of the data has resulted in the development of a better understanding of the potential educational applications for handhelds.

Introduction

International Schools in Hong Kong and elsewhere are increasingly looking for possibilities to extend learning beyond classrooms (see Hattie et al., 1997; Rickinson et al., 2004). Field trips in the sciences (Scanlon, Jones, & Waycott, 2005) and geography (Armstrong & Bennett, 2005; Grundy-Warret et al. 2006) are seen by many to be fundamental to the development of a deep understanding of the discipline. In outdoor educational activities students have the opportunity to learn in an engaging and authentic environment. In our study we envisaged that learning could be made more effective for students if they have handheld devices that allow them to have access to resources and data recording anywhere and anytime.

Handheld devices are nowadays equipped with substantial capabilities such as wireless network connectivity, a mobile phone, camera and a variety of add-on hardware and software extensions that enable voice recording, sketching and access to Microsoft Office documents. These devices have been variously described as Personal Digital Assistants (PDAs), Pocket PCs, "wearables" (Sharples, 2000), and/or "communicators" or "mobile multimedia machines" (Attewell, 2005). More recently, devices that combine PDAs with mobile telephony, smart phones, have become more commonly available (Keegan, 2004; Zheng & Ni, 2006). Handheld devices may assist learners "to access Internet resources and run experiments in the field, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world" (Sharples et al. 2002, p. 222). For Luchini, Quintana and Soloway (2004), the key benefit of PDA technology is as a powerful personal device that "provides access to tools and information within the context of learning activities" (p.135). Studies reported a variety of situations for the use of PDA technology in teaching and learning: during classes, enabling teachers and students to share files (Ray, 2002) and allowing students to ask anonymous questions, answer polls and give teachers feedback (Ratto, Shapiro, Truong, & Griswold, 2003); for delivery of courseware and quizzes and as an intelligent tutoring system (Kazi, 2005); for dissemination of information and collection of data during field trips (So, 2004); as a tool that supports students' inquiries (Clyde, 2004; Sharples et al., 2002); in computer-supported collaborative learning (Roschelle & Pea, 2002; Zurita & Nussbaum, 2004); as personal technology for lifelong learning (Sharples, 2000); as support for more flexible modes of assessment (Vogel et al., 2007), and for disadvantaged young adults to improve literacy and numeracy skills (Attewell, 2005).

How PDAs may be used in teaching and learning depends largely on teacher understanding of the educational affordances of this technology (Klopfer & Squire, 2005). Norman (1988) defines affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (p. 9). For Barnes (2000), a teacher's use of any new technology in teaching and learning is undertaken in the belief that this technology will afford learning in some way. Churchill and Churchill (2008) suggest that there are five potential affordances offered by handhelds: (a) *multimedia-access tool* — a variety of multimedia resources can be provided or created, (b) *connectivity tool* — the technologies available in handhelds empowers students to connect to each other, facilitators and experts in the field, exchange ideas and files (Bluetooth, WiFi, phone), (c) *capture tool* — handhelds are equipped with a variety of media capture capabilities that include video, audio and still photographs, (d) *representational tool* — handhelds can also be used by students to create representations which demonstrate their thinking and knowledge such as mind maps and/or concept maps, diagrams and annotated images (Kennedy & Vogel, in press), and (e) *analytical tool* — a handheld might be used as an analytical tool to support specific student tasks (e.g., special purpose calculator).

Experience from the Field

In February 2007 a group of 32 students, three teachers and a researcher traveled to Northern Thailand. The students were Year 12s from a secondary English Schools Foundation (ESF) school in Hong Kong. The main purpose of the trip was for students to learn some key concepts, acquire skills and engage in developing a deep understanding of key elements of their geography curriculum. It was believed that the trip to Thailand would provide an authentic environment for students' learning where they could, for example, collect data, conduct inquiries, and interact with local people and the geography of the area. We also believed that situating students in an authentic context would add a special dimension to the development of students' geographical knowledge, leading to improvements in their assessment results. The North Thailand venue also provided the required logistical support for the project. This was important as organizing such trips without local support would be a complex exercise.

In previous trips of this nature, students used pen and paper to record data that they collect (e.g., river water velocity), sketch and otherwise record certain details (e.g., shapes of rocks or a sketch of the river bed), write notes (e.g., observed quality of water or observations about village life), or otherwise record data and observations. Access to reference material was limited to paper (e.g., a book or class notes), while essential calculations required access to a calculator. In addition, students were required to carry measurement instruments that were often impractical to manage and carry. In addition, the collating and sharing of data and observations between individual students, teams and teachers was a painstakingly slow process. In thinking about ways to deal with this problem, handheld technologies appeared to offer an attractive solution. However, there were limitations in that we did not have such devices available, and our own understanding of affordances of this technology was limited.

However, solutions to these limitations were quickly found. After discussions with the school's Parent-Teacher Association and the Hewlett Packard (HP) company, sponsorship was secured which provided sufficient numbers of HP iPAQ hw6900 Mobile Messenger for the purpose of the trip. This device uses the Windows Mobile operating system. Availability of the QWERTY keyboard with the iPAQ meant that the screen area of the device was reduced from the standard 320 by 240 pixels to a non-standard size of 240 by 240 pixels.

A framework developed by Churchill and Churchill (2008), provided the means to conceptualize uses of handhelds in the context of the trip. The specific planning for the geographical studies required that students engage in a number of activities. These included river investigations, visiting a number of local villages and examining way of life, investigating vegetation and structure of hillsides, and investigating traffic and pedestrians flow across a major city. These activities were carefully selected and designed by the teaching staff to incorporate opportunities for students to engage with key concepts and skills from the Year 12 Geography curriculum. The students were briefed each morning before heading out to various locations for activities. In the evenings they gathered together to collate and share results, report the outcomes and issues experienced during the day's work and draw conclusions. The specific activities included in the trip revolved around a series of investigations associated with the impact of a river on a community are described below in more detail.

The student activities will be used to illustrate this study involving the explorative use of handheld devices (handhelds). During the study period, students were required to conduct a number of investigations at several distinct and often distant locations on the same river over a two day period (e.g., one location was in hilly terrain closer to the river source, a second location close to agriculturally active villages, and finally a location close to the river mouth). The investigations included:

- taking measurements of the physical characteristics of the river (e.g., velocity, depth and width);
- calculating the rate of river discharge;
- identifying invertebrates in the river sediments and under rocks (e.g., blood worm, or dragon fly larvae) in order to predict water quality;
- conducting tests for components in the water (e.g., pH, dissolved oxygen);
- collecting and comparing samples of the river bed-rocks from various locations.

Different teams of students conducted different investigations at different points on the river. For example, one team would investigate the parameters of the river at one location, chemically test water at a second location, and examine invertebrates at a third location. Simultaneously a second team would examine invertebrates at the location one, determine the river parameters at a location two, and chemically test water at location three, and so on. All the teams would then gather together at the end of the activity and present their data and observations. For example, data regarding chemical properties of water from three locations collected by different teams was shared for analysis and further investigation. The students discussed and differences found by different groups, speculated about factors that might be affecting changes along the river, and developed hypotheses.

A set of educational affordances of handhelds developed by Churchill and Churchill (2008) provided us with the framework for understanding how to utilize handhelds in the context of the river investigations activity. Table 2 presents a summary of applications on the handhelds used in the River Investigations activities.

Table 1: Summary of the applications of handheld in the River Investigations

Affordance of Handhelds	Application in River Investigations Activity
• Multimedia Access Tool	• Reading material as MS Word documents, PDF (Adobe Acrobat) files, and Web pages • PowerPoint presentation slides • Images (diagrams, maps and pictures) • An interactive learning object
• Connectivity Tool	• Using Bluetooth to exchange files and data
• Capture Tool	• Taking images and short videos • Attaching audio notes to images • Audio-recording own observations • Audio-recording teacher explanations • Capturing GPS positions
• Representational Tool	• Sketching diagrams • Sketching information on the captured images • Drawing mind maps
• Analytical Tool	• Using the calculator • Entering data in a pre-configured Excel worksheet to obtain immediate results to particular data sets

Multimedia Access Tool

Initial trials involved with the use of reading material such as MS Word documents, PDF (Adobe Acrobat) files, Web pages, PowerPoint presentation slides and images (diagrams, maps and pictures). These files were downloaded onto SD memory cards and distributed to the students' PDAs. The intention was to provide resources that supported the fieldwork in a portable format. However, subsequent evaluation with students, discussion with colleagues and an extended literature review (e.g., Albers & Kim, 2001; Bradley, Haynes, & Boyle, 2006; Churchill & Hedberg, in press) indicated that:

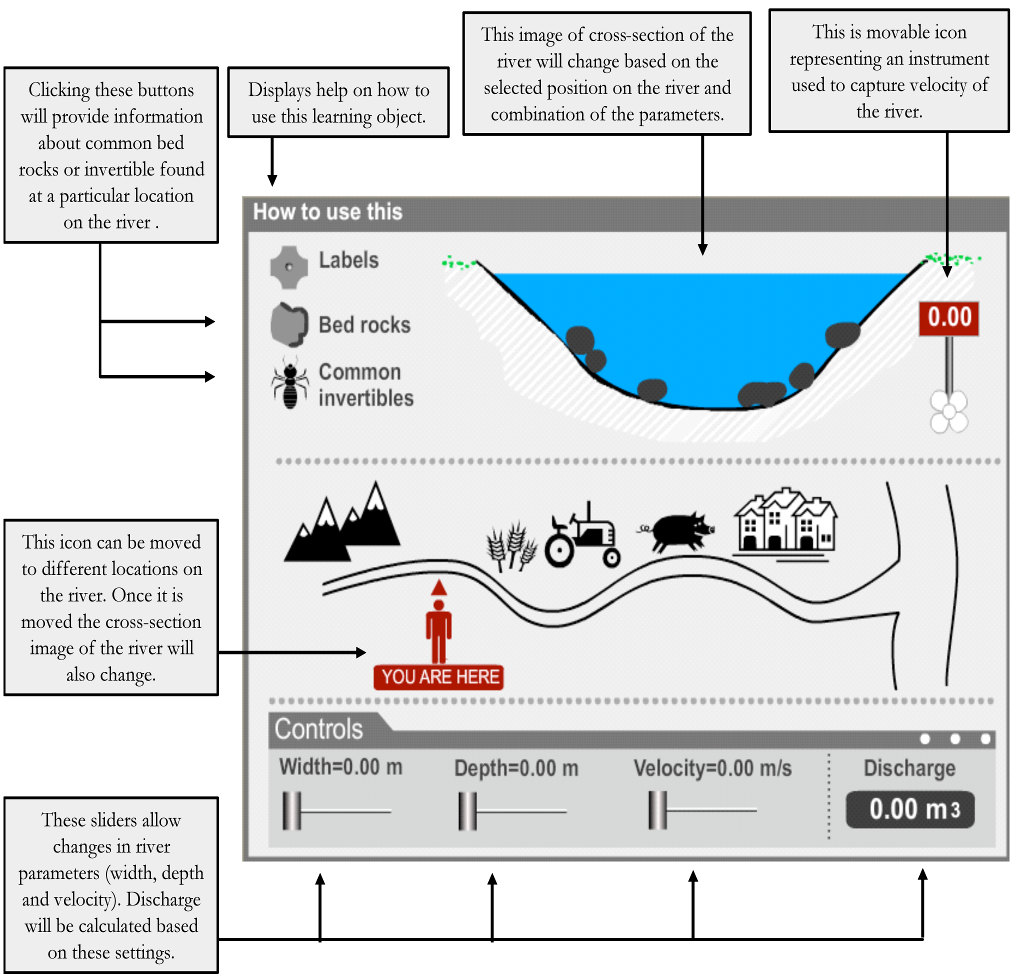
1. Material for presentation on PDAs must take in consideration certain limitations of the screen size. Some material that is designed for computer presentation can be effectively used on handhelds; however, a significant amount of the material needs to be restructured in order to be presentable via small screen and support interaction on handhelds. The guidelines for design of material for handheld use are presented in Churchill & Hedberg (in press).

2. The content of the material must be designed for 'just in time learning'. Usually, students work on some task and access the resource on the handheld to help them to deal with the complexities of that task. Any resources that required users to concentrate and spend time reading and previewing it were seen as 'inefficient' and were less likely to be used. We believe that resources to be used for supporting outdoor activities should be designed in such way to

require minimal sensory contact time with the screen.

Another use of the PDAs included the design and development of interactive multimedia learning objects to support specific learning tasks (Churchill, 2007). Design of interactive learning objects to utilize visual representations and user input can maximize interactions that can be presented on a single display. Potentially, learners are able to learn in shorter time by the scaffolding provided by the learning object rather than through merely reading static information. However, there are very limited numbers of such learning objects available, particularly case for small mobile devices. Our study included the design of some learning objects suitable for the proposed student activities. Figure 1 is a screen capture of the learning object "River Exploration" for handhelds.

Figure 1: A learning object designed for use in the River Investigations activity



The “River Investigation” learning object is best described as conceptual representation (Churchill, 2007). This learning object is designed as a single screen of multimodal information that can be manipulated interactively by students. The learning object supports active learning by students as they explore the scenario described in the learning object, experimenting with different parameters and settings. Interactivity and visualization allow a large amount of information to be summarized and represented in ways that are effective for learning. This particular learning object contains information about and number of important river parameters, enables calculations relating to river discharge, the impact on flow rates caused by the shape of a river bed, and identification of the location of common invertebrates at different locations along the river. Various components of information are presented based on a student’s interaction with the learning object. A student can arrive at a deep understanding of the river system through interaction and manipulation of specific parameters (e.g., how cross-section of the river changes as you move down the river) or by systematic exploration of specific information (e.g., how the river discharge is calculated).

This learning object scaffolds the learning process. Careful design of the interactions, information presented and concepts illustrated in the learning object supports the conduct of the investigation, enhances decision-making and enables construction of more complex conclusions based upon real-world activity. The absence of just-in-time support limits student knowledge construction and development. The learning object provides a powerful set of external conceptual representations related to the specific task.

Such resources can be stored either in the memory of a handheld or an SD memory card and accessed when needed. In addition, handhelds also support direct Internet via built-in wireless; however, this was not possible to do during our trip. Internet access was via the cell-phone network using General Packet Radio Service (GPRS). However, such service from remote locations in foreign countries involves expenses that we were not able to meet without further sponsorship. We informed students that they might use their Subscriber Identity Module (SIM) cards if they wish to make phone calls or send messages by handhelds. Due to the high costs of accessing the Internet from the field, we did not instruct students to make use of this facility. Not being able to utilize Internet services for the transfer of information during the trips represented a limitation. However, in future, we are planning for local area network (LAN) access in the field. In addition, the cost of Internet services is expected to considerably in the future. We are also looking at the possibility of using 3G enabled devices in hope of improving our ability to access the Internet at a lower cost thus providing a more effective networking service. Other key limitation of the particular handhelds using in the study was the limited screen area of the device. A typical screen area of many handheld devices is 320 by 240 pixels.

Connectivity Tool

Inability to use network services in the filed considerably limited our initial intentions. Initially we planned to have students in the field connected to their "buddies" in classrooms in Hong Kong, and exchange data and ideas by uploading resources to a network or use Skype to communicate and exchange files. Although theoretically this was possible, in practice it was too expensive. Instead we used another wireless function available on each device: Bluetooth. Bluetooth enabled students and teachers to exchange files and data, albeit slowly. In the River Investigations activity students shared files within their groups (e.g., images which they took) and teachers could send files to them (e.g., some additional instructions which emerged as being required for the activity). At the completion of each investigation all groups of students uploaded their files to the teachers' notebook computers. Subsequently the teacher collated the data from the different groups into an Excel worksheet. This worksheet was then sent back to the students via Bluetooth for further analysis. Some students themselves decided to use Bluetooth to share various files such as audio or text notes that they made. However, the speed of file transfer using Bluetooth was limited. In future trips of this nature we will be using a mobile server that can be used to set up a local area network (LAN) using a laptop computer and wireless router. This system is based upon the eToken system current used with the learning management system (LMS) Blackboard (Vogel et al. 2007).

Capture Tool

The ability of the handhelds to capture a variety of media proved to be very useful in the context of field studies. The functionalities provided (e.g., video, audio, photographs) allowed students to record their observations in a variety of formats. For example, students were able to record their own audio notes or to record voices of conversations with other students, teachers or sounds from the environment. The handhelds also allowed students to record their audio notes and attach these to captured images. The design of the activity utilized the functionalities of the devices. There was an educational intention that gave students a specific purpose for capturing data in this manner. It was believed that without an appropriate learning design students were unlikely to maximize the use the devices in an educationally constructive way.

For example, during the River Investigations we required students to develop a digital story of their work and present these stories to the class at the end of the activity. Digital stories are a multimedia presentation usually composed of a sequence of images that transit from one to another, accompanied by recordings of narrations, music, effects, text, graphics, and occasionally videos (McLellan, 2006). Digital storytelling is a powerful strategy that supports students' creative expression and supports development of new literacies (Lambert, 2002). Every group of students had access to a notebook computer once they returned to the hotel in the evenings. The students were able to transfer captured media from their handhelds to the notebook after which they worked together to create a digital story of their activities including describing any conclusions that they had made. The act of creating digital story supported students' reflective practice. Simultaneously, the final digital stories served as tools for sharing experience amongst their peers while providing teachers with a better understanding of the students work.

Students were also able to capture and record GPS positions of the places where they conducted their investigations. Students then located the GPS positions on the maps which were stored on the handhelds. However, we found that the captured GPS position produced inconsistent results. Subsequent study indicated that it was the physical configuration of the local terrain where the measurements were taken that was most likely to have caused the inaccuracies.

The affordances of the mobile devices were extended by the development of specific applications. One application was used by students to collect of traffic and pedestrian counts at different intersections around the center of a city (Chiang Mai in the Northern Thailand). The information was then collated and presented on a cluster map. This data was then used by students to discuss and propose potential improvements to city planning. The application allowed a student to quickly record their observations by clicking on the appropriate icon (plus symbol). If a mistake is made, the "-" button removes the record. The data collected can be saved to a separate file which can be then sent to a teacher's or shared with other students.

Representational Tool

Handhelds are also capable of creating of visual representations such as sketches, diagrams, mind maps and sketching information over captured images. For example, students could sketch the shape the river bad and attach labels indicating collected measurements in preparation for later use in their development of digital stories. Mind mapping also assisted students to organize their observations into forms that are more effective for latter reuse and communication to others (e.g., mind map showing a classification of the invertebrates located in the river). These representations can also be sent via Bluetooth to a teacher who can use them to provide feedback to students about their thinking and understanding of the relevant concepts. One tool developed specifically for annotating images is Phototate (Kennedy & Vogel, in press). The Phototate application allows students to annotate a photograph with text, sketch or outline features in different colors using a pen tool, and attach an audio file to the annotated image.

Analytical Tool

Powerful computer processing capabilities of handheld technology provided some effective tools in outdoor educational activities in our project. The students were making use of the calculator available on the handhelds to carry on various calculations (e.g., averaging depth of the river). In addition, we also provided some Excel worksheets where student could enter certain variables and automatically receiver output values. In this context, these worksheets served as special purpose calculators. Some students also attempted to use the learning objects featured in the Figure 1 as an analytical tool. They adjusted width, depth and velocity of the river to values which they collected by measuring the river parameters to automatically obtain analyzed value of the river discharge.

Conclusion

As the handhelds become increasingly available to our students it is important to further our understanding how these technologies can benefit teaching and learning. Handhelds today are powerful technology that contains capabilities such as wireless network connectivity, a mobile phone, camera and a variety of add-on hardware and software extensions. This paper described and exemplified five key affordances of this technology for teaching and learning: multimedia-access tool, connectivity tool, capture tool, representational tool, and analytical tool. Our experience from the field trip with students demonstrates that the students were able to effectively utilize these affordances for learning, data collection, collaboration and reflection. Our further research efforts concentrates on study of effective design of learning objects and other forms of multimedia for pedagogical applications via handhelds. As this technology continues to become more powerful in technical capabilities, and in particular as more of today's so called Web 2.0 tool and services are becoming available via handhelds, we foresee that these will become increasingly more important in education.

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