Tracking Observations: Using Handhelds and Computers for Classroom Observation Logging

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Abstract— **This paper presents the synergistic use of handheld computers and desktop computers as tools for grade school teachers to record observational data from their classrooms. The system uses handheld devices to tersely log events in situ, and allows later reflection and elaboration through annotation of the logged events on desktop computer. The terse, ephemeral capture of events coupled with post-hoc annotation has been novelly exploited to design a system that supports teachers' development as reflective practitioners and enables richer capture of grade school student behaviour and performance.**

I. Introduction

While many researchers have attempted to design mobile information capture applications for Personal Digital Assistants (PDAs), the applications have met with limited success. Commercial applications exist that transform PDAs into information sources, but the use of PDAs as mobile information capture tools is still an area where further refinement is needed. One reason for this lack of information capture is undoubtedly limited input capabilities; PDA input occurs via a stylus and touch screen, occasionally augmented with thumb keyboards. As a result, the recording of extensive amounts of information is unwieldy. Despite limited input, PDAs are powerful mobile computers, making them ideal for mobile information capture if appropriate applications are designed.

This research project's goal was to understand the current work practices of elementary (kindergarten through grade six) school teachers and to design information technology solutions to improve information capture and management for student tracking. The primary vehicle for student assessment and tracking is observational notes made by teachers during their interactions with students in class, as shown in Figure 1. Teachers record observations for several specific purposes, including the need to evaluate student performance at reporting times (summative assessment), to identify areas of student weakness and current student level to inform instruction (formative assessment), to track student behaviours (social assessment), and to measure their own success in communicating ideas to students (self-assessment). While some computer applications exist for student observation, these applications are awkward to use and require careful data input, resulting in an on-going use of pen and paper for observation logging both in the classroom and during grading outside the classroom. Using pen and paper, however, requires transcription onto computer or into some ledger-based format to track student improvement over time and to generate numeric or letter grades at reporting time, resulting in information fragmentation.

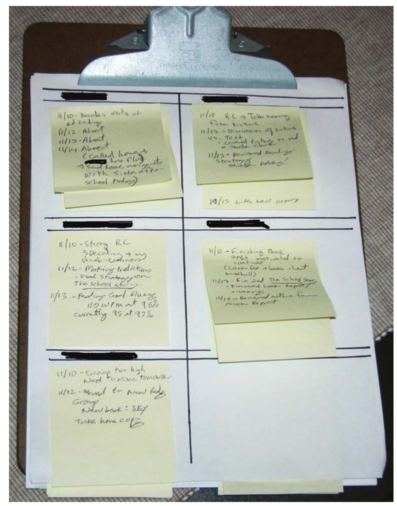

Fig. 1. Classroom observations.

In this paper, we describe the design and implementation of a handheld and computer based student tracking tool for use by grade school teachers. Handheld devices serve as logging tools to tag occurences in class, while the desktop system allows synthesis and tracking of overall performance by refining the tagged occurences into observations through annotation. One result of this research has been an enhanced understanding of how rapid data capture and refinement can occur by the combined, complimentary use of handheld computers and desktop computers.

This paper is organized as follows. We first describe the recording and reporting needs of grade school teachers. Next, we describe the software system developed to support teacher recording and reporting functions, and its validation. Finally, we outline related work in mobile information capture.

II. Teaching Practice

To identify the need for information capture for school teachers, we conducted a series of interviews with grade

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school teachers in a three-phase study. We first conducted a pilot interview with one grade school teacher to identify challenging areas of work practice and to inform discovery (pilot phase). We then conducted a series of in-depth, show and tell style interviews with two grade school teachers (one 4th/5th grade and one 6th grade) at two different elementary schools to analyze work practice and design and implement an observation capture application (design phase). Finally, we concluded by conducting six additional interviews based around our system design to validate our results (validation phase).

There are many differences between the two subject teachers in the intermediate (design) phase of our study in terms of teaching style. There are also major differences in each of the teacher's schools as they are located in different areas and populated by students of different socio-economic backgrounds. Their classrooms are composed of students who possess an understanding of the given instructional material on a variety of different levels and it is the teacher's responsibility to make a single lesson beneficial for all students. Each student has a unique set of academic strengths and weaknesses which must be identified and monitored. Additionally, teachers must be sensitive to the unique social needs of each student. Some students may be distracted by the proximity of certain students while other students may respond to instruction differently at different times of day. Students also exhibit unique behaviours which teachers wish to track.

Elementary school teachers currently attempt to program for individual student differences by logging academic, behavioural, and social observations about individual students in paper notebooks. These observations then inform instruction. One teacher showed us a system involving a clipboard with a stack of 2x3 grid paper (one grid per student) and post-it notes on each grid cell. Interviews with teachers in our validation phase confirmed that this observation organization technique is common, and is called an *observation grid*. The other teacher was slightly more disorganized, typically capturing observations quickly after class on scraps of paper for later transcription into their "good" gradebook (i.e. the neat grade book they show to parents and the principal), another common technique, particularly among grade four through six teachers in our validation interviews. All teachers periodically review their notes in order to monitor the academic and social tendencies of each student and adjust their instruction and classroom environment accordingly. As examples of tracking over time, Figure 2 shows, from left to right, one teacher from our design phase tracking student attendance and calling home when concerned, an observation of student performance for numeric or letter grading, and a reorganization of reading groups based on observations of a student struggling with reading material.

In grade school classrooms the paper-based systems are problematic since they do not provide the teacher with an effective method of quickly logging observations when they occur during class. Teachers are reluctant to record observations when a student struggles with difficult material or during misbehaviour, particularly in grades 3 - 6 classes. The purpose of observations is neither to stigmatize, nor to discipline. If older elementary school students are aware of the frequent observations, they become self-conscious of errors and/or act out. As a result, the teachers often log their observations at the end of the day or during breaks when many observations may have been forgotten. Furthermore, logged observations are often meaningless without a chronological context and the paper-based systems are not an effective way to analyze academic and social trends over time. Similarly, the paper notebooks make it difficult for the teachers to draw connections between different observations in order to integrate distinct observations into a meaningful hypothesis. Also, the teachers do not currently have a way to present their observations compellingly to parents during parent-teacher conferences.

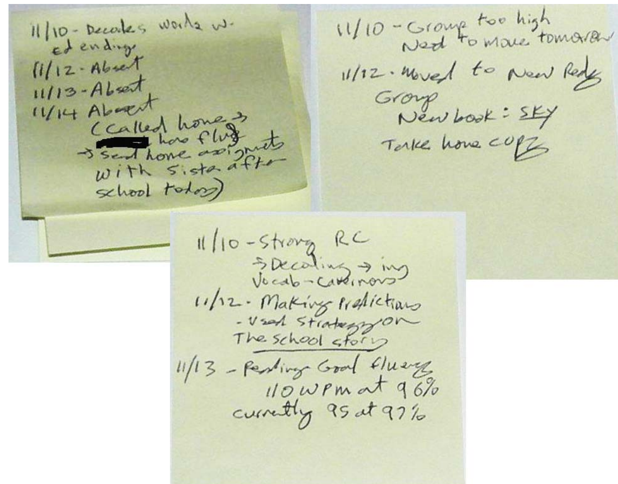

Fig. 2. Detailed notes on individual students.

There is some precedence for the use of a software solution to address some of these problems, as both teachers describe experience with two systems designed to track raw academic performance. One of these systems focuses on visualizing the results of certain standardized tests over time. The other system is broader in scope but too difficult and time-consuming to use in class. Interviewing additional groups of teachers has validated the fact that personal computer based applications exist for observation logging, but no teacher we encountered uses these applications.

III. System Design

A. Design Principles

Working with two target teachers during our design phase, we iterated on a series of systems using both low and high fidelity prototypes. Several design principles arose during our discussions, many of which are obvious in light of teacher work practice. These include:

- **Lightweight capture:** Any system must support quick capture of an event without requiring extensive user attention. Teachers want to note observations without interrupting classroom activities.

- **Log then annotate:** The process of recording notes on student action after class, away from students, is a desired work practice teachers wish to preserve. The challenge with such an approach is that observations are forgotten. Rather than designing an observation capture tool, an observation logging tool for classroom use, coupled with some post-hoc annotation for reflection on teaching practice is desirable. In this way, teachers avoid forgetting observations, yet are still encouraged to later reflect, analyze and elaborate. Support for the development of 'reflective practitioners' was frequently cited as a valuable contribution of the log/annotate system that evolved from our discussions.
- **Flexibility:** Occasionally it is possible, in class, to collect more detailed observations, while at other times observations must be very brief. Also, sometimes detailed notes on an observation are important, while at others only a positive or negative impression is needed. Teachers would also like the flexibility of logging different granularities of observations in class (one-click, two-click, or three-click, for example) as time permits. Furthermore, the flexibility to selectively annotate observations after class with varying levels of detail is also desirable.
- **Simple tracking and correlation:** One of the drawbacks of paper-based systems is that data analysis is only superficial. The ability to track one student is possible, though it remains difficult to chart and present to parents student progress over time. However, with paper-based systems the process of correlating behaviours of students with activities is very difficult, especially due to lost timing information. Some simple presentation of behaviours over time is desirable.

B. Target Platform

Two technologies are appropriate for mobile electronic information capture in class: digital pens such as Anoto devices and PDA devices. An Anoto-based pen writes using physical ink. If the pen is used to write on special 'digital' paper containing a background dot pattern, stroke location and timing information can be captured by a camera in the pen and transferred to a computer.

We chose PDA devices for several reasons, including cost (PDA-based cell phones are subsidized) and speed of clicking versus writing. Also, the need to manually assign data from a digital pen to corresponding student requires some digital paper widget or manual coordination, further slowing observation logging or data synchronization. Finally, a handheld device need not make past observations visible on the screen, protecting the privacy of individual students and the surreptitious character desirable of observations of older students.

C. Design Evolution

Early in system design, designers and teachers identified two specific subtasks in observation capture, logging and annotating. Logging is a temporal stamp associated with an observation, basically a statement that something happened at a certain point in time that was worthy of noting. Annotating is the process of elaborating on a logged incident to transform it into an observation. One design teacher noted that this is frequently his or her practice with paper, i.e. making very short, informal observations that can later be expanded into an observation when students are not present. This process is also considered good practice, and is encouraged as a component of teachers' development as 'reflective practitioners.'

We implemented a two-tier observation system delineated into the logging and annotating subtasks. The first tier of the system is the Observation Logger, an application on a PDA which displays a diagram of the tables/desks in the classroom with the name of each student in the appropriate position (Figure 1). When the name of a student is clicked, a new screen appears which displays a set of categories. When one of these categories is clicked, a new screen appears with a set of sub-categories. Each sub-category is divided into a positive (+) and negative (-) region. By touching a sub-category element in either region, an incident is logged in the system and a timestamp is assigned to this incident. Control is returned to the main screen which displays the classroom layout and the teacher is free to log another observation.

At the end of the day or during a break, the teachers can annotate their logged observations with meaningful text on a personal computer using the Observation Viewer (second tier). The observations which were logged on the PDA will appear in the calendar view of the Observation Viewer along with the corresponding timestamp, category information, and +/- hint. The annotation process relies on the teacher's capacity for short-term memory, cued by the logged data. The assumption is that the category structure, the timestamp, the student's seating location, past knowledge, and work collected from students collectively provide the teachers with enough information to enable them to remember the observed incident later in the day.

We tested prototypes several times with the elementary school teachers through walkthroughs in order to collect feedback and refine our design. One observation was that the system should be flexible enough to allow for an observation to be recorded in a variable number of clicks (with an increasing level of detail) depending on the amount of time the teacher has in that particular moment. If the teacher has enough time s/he can log a 3-click observation by drilling down to the sub-category level but s/he would also like to be able to quickly log a 1-click observation by touching the name of the student. In response to this feedback, we revised the design of the Observation Logger to accommodate this flexibility. By stroking to the left or right within a student's name, the teacher can record either a negative or positive, uncategorized observation. Clicking expands into sub-categories which support stroking to record at the second level, or the teacher can drill down to a third level by clicking again. As one example of this, consider the disruptive pencil tapping of one student. If necessary, the teacher can record a single, negative observation. However, if

Fig. 3. Observation Logger on PDA device. Student identities are anonymized.

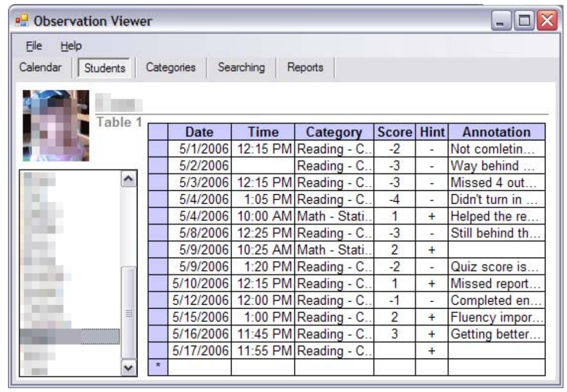

Fig. 4. Observation Viewer showing browsing by student. Student identities are anonymized.

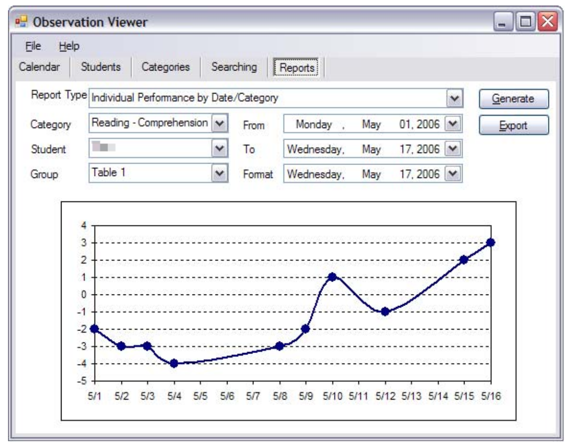

Fig. 5. Summary report of observations in the Observation Viewer. Student identities are anonymized.

time permits, the teacher can click on the student's name and record a negative behaviour on a second screen, or click on behaviour and record a pencil-tapping event on a third screen. The final interface is shown in Figure 3.

The pencil tapping scenario also highlights another piece of feedback, specifically that the system should be flexible enough to provide for end user modification of categories. At the beginning of the year, generic default categories would suffice (academic, behavioural, etc.) but as teachers begin to make observations about students and notice trends, they would like to be able to narrowly define the incidents which they are tracking (e.g. pencil tapping). They also noted that these incidents would be different for different students. To meet this requirement, we provide a category view in the Observation Viewer which allows teachers to create and manage additional observation categories.

It was also important to support flexible browsing of observations in the second tier. Teachers wanted to browse observations by calendar date so they can view a chronological representation of their observations. Browsing observations by student was also desirable in order to obtain a quick history of a student. In addition to annotating and browsing past observations, the teachers expressed an interest in summary reports from the recorded observations. These reports could help the teachers analyze the observations in a variety of ways to track progress and detect patterns. For example, a teacher may wish to view a report which summarizes one observation category, for instance to monitor group behaviour issues.

The Observation Viewer provides a number of tools and views of the observation data to assist in editing and analysis. The Observation Viewer helps the teacher organize and analyze newly collected data, so that it can be put to practical use in an organized way. Observations can be viewed and edited by calendar date, or for individual students (Figure 4). Teachers may also customize the category list and table layout to suit their needs. The reporting panel provides a graphical view of the observation data (Figure 5).

D. Validation Phase

We conducted interviews with six additional teachers to validate and improve the observation recording system. The interviews were semi-structured, involving a walkthrough of the system and features, coupled with questions on how the teachers currently capture observations, how well the system would suit them for capturing observations, and additional features that were needed for effective observation capture. We also asked about overall impressions of the system, and whether or not the system could be used in their classroom environment. Several comments from these interviews merit noting.

Suggestions to improve the system result from the heterogeneity of students in grade school. Grade school covers children whose ages vary from 4 years to 12 years. Comments by a kindergarten and grade two teacher indicated that the observations of younger children need not be as surreptitious, and that digital photographs and audio annotation would be useful additions to information capture. On the other hand, for older students, a grade four teacher who covered drama noted that more rapid numerical grading would be beneficial.

Grading is done typically in 'levels' (Level 1 students do not understand, Level 2 students do understand, Level 3 students can repeat on similar problems, and Level 4 students can extend and apply to different problems), and direct access to these levels is important in subjects such as drama. While our system provides levels through repeated observations, explicit access would speed in-class grading. Both multimedia capture and basic numerical observations have been integrated into the second version of our system.

All teachers note the benefit that can accrue from effective observations. One kindergarten teacher noted that entire workshop sessions are devoted to observation capture, management, and use. All noted the lack of good software tools to simplify capture. In addition, five of the six teachers thought the system usable in their classroom environment. One teacher had poor vision, and had different glasses for reading and distant vision. This teacher cannot record observations in class using paper due to visual challenges, and thought that the capture of photographic and/or audio data might allow some form of real time observation capture.

One key comment from teachers is the universal benefit of log then annotate information capture in classrooms. Having efficient tools to support this process allows teachers to generate more frequent and complete observational and grading data for students, is considered highly valuable in both lesson planning and summative assessment, and enforces the observe-reflect practice they are encouraged to use for self-assessment.

IV. Related Work

Many authors have presented studies of information capture on mobile devices, though no studies of electronic teacher observation capture were located in the literature. Also, studies of tag and recall systems and of the synergistic use of handhelds and other computers relate to our work.

A. Mobile Information Capture

Mobile information capture and retrieval and handheld computing have strong synnergy, a result of the need for computing power to place no restriction on mobility. Examples of the use of PDAs as location-aware guides in indoor environments [2] or theme parks [10], or as guide systems for use on university campuses [5] are instances of PDA use as an information source. Similarly, in their work with emergency response, Sawyer et al. note that the 'killer application' for first responders is a mobile device which provides access to a database of driver license photos [16]. While these projects have studied mobile devices as information appliances, our goal has been the design of applications to support information capture in mobile settings. Research has also been performed on scheduling, a user task that motivates most PDA purchases [18]. One key observation from research on scheduling practice is how frequently users abandon their PDA and resort to scraps of paper to avoid the access time penalty of PDAs.

One significant use of PDAs for information capture is the work by Pascoe et al. for use in observing animal behaviour and in archaeology [11]. Pascoe et al. specify design rules for minimally attentive user interfaces, or MAUIs, which are designed to allow information capture without attending to the display. Our application interface is an instance of a MAUI. However, Pascoe et al. did not explore the synergistic use of computers and handhelds in their research.

In education settings, researchers have introduced handheld computers as educational appliances for students occasionally supporting information capture. Cole and Stanton describe a series of applications developed specifically for children [3], including a data collection application (Ambient Wood) to collect environmental measurements. In addition, Sharples et al. describe an 'experience capture' application for handheld computers that teaches lifelong learning by allowing archiving of everyday experiences and subsequent reflection upon them [17]. Sharples et al.'s work has some similarities to ours, as events are captured and later reflected on, but the reflection is presumed to be internal or among classmates. Teacher use of these devices for observations is not explored, and post-hoc refinement is given terse treatment.

More recently, researchers have explored digital pen and paper technology, such as Anoto's enabled paper and camera pens, to transition between paper and electronic formats for mobile information capture. The ButterflyNet project explored the use of Anoto pens, digital cameras, and GPS for information capture, and a browsable digital repository of information on a desktop or laptop computer as a vehicle for browsing information [20]. Tools supporting the transition between paper-based capture and numeric format were developed, for example a digital ink to spreadsheet transcription tool for transcribing numeric data by automatic scrolling. The ButterflyNet project, similar to our work with teachers, exploits the synnergy that exists between mobile information capture of informal data and desktop applications to refine data. However, refinement is limited to transcription and browsing tasks, rather than elaboration on captured data.

B. Capture and Tag Systems

The work practice of teachers evaluating students' classroom interactions is an instance of a 'capture then tag' system. While information tagging systems such as Flickr, Del.icio.us, and others have met with some success among the technosavy, researchers have noted the lack of broad use of tagging [4], [13]. Studying photo work as a primary domain where post-capture tagging is important for organization has demonstrated that organization and tagging of photos, unlike teachers' classroom observations, is an activity typically done prior to sharing, rather than immediately after capture [7]. Research has also been done on incentive based techniques for information tagging; for example, von Ahn and Dabbish introduced a game for tagging images on the web to provide better search [19]. However, in our research, incentives already existed for information tagging, so incentive-related research to encourage tagging is only tenously related.

Teachers are motivated to both capture and tag early. More commonality exists between teachers and subjects in diary studies, where tagging must be done to capture information, than between teachers and photo taggers, where the act of tagging might partially enhance use, but the incentive is low. Researchers studying diary studies as a means of data collection have noted that, with motivation and a relatively low burden, end user information capture can provide an effective means of collecting data [12], and that users are willing to capture information in appropriate detail. Recent work by Carter and Mankoff on information capture during diary studies [1] focused specifically on how to maximize information capture by subjects. They analyzed data from several diary studies that exploited different capture techniques, examining specific factors that affect the recording of information. They also make several suggestions for improved diary studies. In particular, for effective information capture in diary studies, they note, among other observations, that in situ event tagging or capture must be lightweight and that later elaboration and annotation should be supported and encouraged. They also study the rich data that can result from the collection of tangible objects in a diary study of visitors to a festival. Our study of teachers highlights similar principles, namely lightweight in situ event tagging and the use of these tags together with student work and memory to elaborate on events.

C. Using Handhelds and Computers Together

The ButterflyNet project is one example of the complimentary use of handheld devices (digital pens and small handheld computers) and desktop computers in tasks. Another, the Pebbles project, studied how computing and user interface functionality can be spread across heterogeneous computing devices [9]. The project explored shared environments and how individuals might synergistically use heterogeneous computers simultaneously. Various synchronous multimachine user interfaces - to control applications by using handhelds as an input/output peripheral with buttons and menus, to control desktop scrolling, to provide additional customizable interfaces to desktop applications, to switch between desktop applications, to transfer information between handhelds and computers via communications protocols, and as a universal remote control for devices - were developed and analyzed. While the Pebbles project studied the synchronous use of handhelds and PCs, with the handhelds serving as real time mobile input and control devices, we instead study information capture using handheld devices, and the role that handhelds and PCs can collaboratively play in information capture and refinement. Our development of log then annotate systems seems most similar to prior work on information tagging, yet with differences resulting from the unique practices of teachers. We posit that the design of observation systems for grade school teachers has illustrated a synnergistic use of handhelds and PCs that extends beyond the work in the Pebbles project, the ButterflyNet project, and on MAUIs.

V. Conclusion

In this paper, we describe our work designing technology to support grade school teacher observations of student classroom performance and behaviour. Handheld computers serve as a logging device, to cue teachers to classroom occurrences, while desktop computers serve as a vehicle for elaborating on the logged observations. The process of separating data capture into simple logging on mobile, limited input devices, and later elaboration on more capable desktop computers has proven beneficial for teachers' development as reflective practitioners and enables richer, more consistent student tracking.

Acknowledgment

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References

[1] S. Carter and J. Mankoff, "When Participants Do the Capturing", ACM CHI 2005 Proceedings, pp. 899 - 908.

[2] Ciavarella, C. and Paterno, F. The Design of a Handheld, Location-Aware Guide for Indoor Environments. *Personal and Ubiquitous Computing*, Vol. 8 (2004) 82 - 91.

[3] H. Cole and D. Stanton, "Designing mobile technologies to support co-present collaboration", *Personal and Ubiquitous Computing*, Vol. 7 (2003), pp. 365 - 371.

[4] G. Furnas, C. Fake, L. von Ahn, J. Schachter, S. Golder, K. Fox, M. Davis, C. Marlow and M. Naaman, "Why Do Tagging Systems Work?", Panel Discussion, ACM CHI 2006 Proceedings Volume 2, pp. 36 - 39.

[5] Griswold, W., et al. ActiveCampus: Experiments in CommunityOriented Ubiquitous Computing. *IEEE Computer*, Vol. 37:10 (2004), 73-81.

[6] M. Hammontree,P. Weiler and B. Hendrich, "PDA-Based Observation Logging", ACM CHI 1995 Proceedings, pp. 25 - 26.

[7] D. Kirk, A. Sellen, C. Rother and K. Wood, "Understanding Photowork", ACM CHI 2006 Proceedings, pp. 761 - 770.

[8] E. Lank, K. Withee, L. Schile, and T. Parker, User-Centred Rapid Application Development, *Rapid Integration of Software Engineering Techniques, RISE 2005*, N. Guelfi and A. Savidis (Eds.), LNCS Vol. 3943, pp. 34 - 49.

[9] B. Myers, "Using Handhelds and PCs Together", *CACM* 44:11, 2001, pp. 34-41.

[10] Yoshiki Ohshima, John Maloney, Andy Ogden, "The parks PDA: a handheld device for theme park guests in squeak", ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications, OOPSLA 2002, pp. 370 - 380.

[11] Pascoe, J., Ryan, N. and Morse, D. Using While Moving: HCI Issues in Fieldwork Environments. ACM TOCHI 7, 3 (2000), 417 - 437.

[12] J. Rieman, "The Diary Study", Proceedings of INTERCHI 1993, pp. 321 - 326.

[13] K. Rodden and K. Wood, "How Do People Manage Their Digital Photographs?", ACM CHI 2003 Proceedings, pp. 409416.

[14] Rogers, Y., Price, S., Fitzpatrick, G., Fleck, R., Harris, E., Smith, H., Randell, C. Muller, H., O'Malley, C., Stanton, D., Thompson, M., and Weal, M. "Ambient Wood: Designing New Forms of Digital Augmentation for Learning Outdoors." Proceeding of the ACM Conference on Interaction Design and Children, IDC 2004, pp. 3 - 10.

[15] Nick Ryan, Jason Pascoe and David Morse, "FieldWorker Advanced 2.3.5 and FieldWorker Pro 0.91", *Internet Archaelogy*, Issue 3, Autumn 1997.

[16] Sawyer, S., Tapia, A., Pesheck, L. and Davenport, J. Mobility and the First Responder. CACM 47:3 (2004), 62 - 65.

[17] M. Sharples, D. Corlett, and O. Westmancott, "The Design and Implementation of a Mobile Learning Resource", *Personal and Ubiquitous Computing*, Vol. 6 (2002), pp. 220 - 234.

[18] T. Starner, C. Snoeck, B. Wong and R. M. McGuire, "Use of Mobile Appointment Scheduling Devices", ACM CHI 2004 Proceedings, Volume 2, pp. 1501 - 1504.

[19] L. von Ahn and L. Dabbish, "Labeling images with a computer game", ACM CHI 2004 Proceedings, pp. 319-326.

[20] Yeh, R. B., Liao, C., Klemmer, S. R., Guimbretire, F., Lee, B., Kakaradov, B., Stamberger, J., and Paepcke, A., "ButterflyNet: A Mobile Capture and Access System for Field Biology Research", ACM CHI 2006 Proceedings, pp. 571 - 580.