Using netbooks to support mobile learners' investigations across activities and places

Mark Gaved[a], Trevor Collins[b], Paul Mulholland[b], Lucinda Kerawalla[a], Ann Jones[a], Eileen Scanlon[a], Karen Littleton[c], Canan Blake[a], Marilena Petrou[a], Gill Clough[a], Alison Twiner[a]

[a]Institute of Educational Technology

[b]Knowledge Media Institute

[c]Faculty of Educational and Language Studies

The Open University, Milton Keynes, UK

Abstract

We explore how small format laptops ('netbooks') have been used within evidence based investigations undertaken by secondary school students, to what extent these are suitable for effectively supporting learners across different locations and contexts, and their implications for open learning. Over the course of seven trials with 300 students and seven teachers we have gathered data on how netbooks have been used in formal and informal learning contexts, bridging school, field locations, and home. The netbooks have supported individual, group and class tasks, and acted as both standalone and networked devices. Three themes have emerged: the use of a single device to support inquiries across activities and places; student use and appropriation; and organisation and management. We conclude that netbooks are a category of device that can be highly effective in supporting open learning though careful consideration is required when considering their deployment and use.

Introduction

In the last two years, there has been an explosion in the number of mobile computing devices available and a corresponding range of opinions have been offered as to how these might be employed within education. Many authors claim wireless, portable technology will have a role to play in the way we learn, and have a large impact on types of learning (e.g. Roschelle 2003; Patten, Sanchez, and Tangney 2006) and there have been many studies of various devices to support learning (Naismith, Lonsdale, Vavoula and Sharples 2005). Studies have focused on two main form factors: the mobile phone and the Personal Digital Assistant, or PDA (e.g. Laouris and Eteokleous 2005; Traxler 2005). More recently though, there has been the emergence of small laptops commonly referred to as 'netbooks'. Initiated by the launch of the One Laptop Per Child and Asus Eee PC computers, this niche has now blossomed to dozens of different models, and most major computer manufacturers offer one or more versions (Kraemer, Dedrick, and Sharma 2009). It is these devices that we will focus on in this paper.

The Personal Inquiry (PI) project, a three year EPSRC/ESRC funded exploration of personal inquiry learning, has been particularly interested in how mobile technology may be used across learning contexts. The project is led by the University of Nottingham and the Open University, Milton Keynes, working with partner schools in each location, and supported by ScienceScope, a developer of science sensing equipment for education. We are researching how school students aged 11-15 can be helped to learn the skills of evidence-based inquiry and how learning can be supported across formal and informal settings. We argue that mobile technology can support the transitions made by learners across settings. The project started just as the Asus Eee PC netbook was launched, and the project decided to choose this, rather than mobile phone or PDA format devices, as the central mobile computing platform for its investigations.

Between September 2007 and November 2009 we undertook seven trials in two schools working with over 300 students. Three trials were undertaken in Nottingham, and four trials in Milton Keynes. Trials were agreed with teachers in the school and based around students undertaking authentic school inquiries. This paper focuses on the four Milton Keynes trials, a collaboration between the Open University research team and Oakgrove School, and explores how well the netbooks performed as mobile learning devices for education; we discuss our learning approach and educational outcomes elsewhere (e.g. Conole et al. 2008; Anastopolou et al. 2008). We will discuss the reasons for choosing the netbook as the project's central platform, our experiences using it in the field with students and teachers, and lessons learnt about how well it performed as an educational device, and implications for open learning.

Inquiry learning

De Jong (2006) defines inquiry based learning as involving learners asking questions about the natural or material world, collecting data to answer those questions, making discoveries and testing those discoveries rigorously. We have developed a "scripted personal inquiry learning" approach to support students and teachers undertaking scientific investigations across formal and informal settings resourced by an inquiry learning toolkit (Mulholland et al. 2009). This 'PI toolkit' consists of a software application called 'nQuire', together with associated hardware support for conducting the inquiry (cameras, GPS data receivers, and data loggers with a range of sensors such as anemometers and digital thermometers).

A key educational challenge facing teachers is how to ensure that the overall educational experience for students is one that is genuinely cumulative and reciprocal, rather than simply extended in time (Alexander 2004; Mercer and Littleton 2007). The investigations supported by the PI project and undertaken by the students ranged over several weeks, in some cases months, and maintaining continuity was critical. As Barnes (1992) has observed: 'Most learning does not happen suddenly: we do not one moment fail to understand something and the next moment grasp it entirely' (p123). Thus, the teachers involved in the project needed to maintain continuity between ideas and events across time. Teachers also had to confront the complex issue of how to support and resource the development of linked 'chains of inquiry' (Scanlon et al. 2009). A key challenge therefore for the Personal Inquiry project has been to identify a mobile device that can help link the phases of learning that a student undertakes and support this continuity of learning across settings.

Mobile learning

Sharples (2009) defines mobile learning as *"learning that happens across locations, or that takes advantage of learning opportunities offered by portable technologies".* The Personal Inquiry project, supporting learning across school, field and home contexts and all phases of an inquiry is a form of education in which the learner is mobile, and therefore has a pragmatic need for appropriate technologies to support learning activities persistently across all learning contexts (Collins et al. 2008).

A range of research projects have explored the potential of mobile technologies for supporting learning. Mobile technologies have been described in terms of: the kind of activities they can support (Roschelle 2003), theory based categories of activity (Naismith, Lonsdale, Vavoula, and Sharples 2004), educational affordances (Klopfer and Squire 2005) and frameworks that view the mobile design space "in terms of both application function and pedagogical underpinning" (Patten, Sanches, and Tangney 2006). Until recently, focus has been placed on PDA format devices and smartphones, investigating the affordances that these devices provide: e.g. brief note taking, simple text messaging, telephony, and use of inbuilt tools such as cameras and wireless connectivity (Trifonova and Ronchetti 2003; Pettit and Kukulska-Hulme 2008).

Many studies to date have focussed on mobile devices that support a single aspect of inquiry, frequently the data collection phase. The PI project has sought to find a device that can bridge all contexts and phases of an inquiry including: background reading, hypothesis generation and planning in the classroom, data collection in the field or at home, and analysis and reporting (including the generation of data tables and graphs). We identified a set of criteria to compare devices, including: form, weight, input devices, screen size, camera, audio, processor, memory, operating system, web client, web server, web scripting languages, databases, communication support, battery life and cost. Table 1 illustrates a selection of these features for five of the considered devices. From our research and initial tests with four devices (Nokia N600, HP iPaq hw6915, Fujitsu Siemens Loox T830 and HTC Qtek 9100) we had concerns that certain functionalities of these PDA and phone format devices would limit their use as devices that could be used across all contexts and phases of an inquiry, namely: the typing speed on small or virtual keyboards; the limited range of applications available for Windows Mobile and Internet Tablet based devices; the lack of standard hardware ports (e.g. USB or Ethernet); small screen size and, compared to the open-source communities for standard operating systems, the relatively small and specialised developer communities.

[Table 1 here]

The decision was taken to use the Asus Eee PC (which we will refer to as the 'netbook'), as it most closely met our list of required affordances, and also benefitted from a simple icon-based user interface, ordering programs by function including 'Internet', 'Work', 'Learn' and 'Play'. This machine had been designed by the manufacturers to meet the needs of school children and first-time computer users and we felt the design was appropriate for secondary school aged children. Kukulska-Hulme (2007) notes that many mobile devices in learning have been designed for business use, rather than education and this can lead to learners experiencing usability issues. Our decision was reinforced by one of the senior teachers commenting at an early design meeting that the school was not in favour of PDAs as mobile devices. Additionally, both partner schools participating in the PI project have a policy of not allowing students to use mobile phones in school, so the use of phone format devices could have created tensions around managing their use within the partner schools.

Case studies

The Milton Keynes trials were based on the topic "My Environment" and The Open University research team worked alongside staff in the Geography department at Oakgrove School. Teachers and IT technicians in the school were given the netbooks to try out before the trials to enable them to gain familiarity with the devices. Student access to the netbooks was managed by the teachers and varied from trial to trial, ranging from access only during fieldwork and classroom sessions, to longer-term home loans. These inquiries can be broken down into three overall stages: preparation in the classroom, data collection in the field, and then analysis and reporting back at school. In some cases this final stage was extended by students working on their reports at home.

Urban Heat Islands (2008 and 2009)

The first trial undertaken was a geography coursework project for students aged 14-15 who were studying for their national General Certificate in Secondary Education (GCSE) in Geography. This was repeated again the following year as our third trial with iterations made following our experiences in 2008. The teachers asked that we support the entire year group (70 students in 2008, 58 students in 2009) rather than a selection. The students started their coursework project in mid February and the submission deadline for their completed reports was at the beginning of April. The topic for the project was Urban Heat Islands – the climatic phenomenon where an urban area maintains a higher temperature than the surrounding rural area due to local environmental conditions. Students would be expected to undertake a literature-based research into urban heat islands (UHIs), carry out fieldwork, and write their coursework assignments which would be assessed nationally.

Students were first introduced to the topic of UHIs in a series of classroom lessons, and introduced to the equipment. The fieldwork consisted of a data collection activity where the students walked across two towns measuring and recording local conditions at agreed locations. Students were divided into groups of four or five, and each group was responsible for taking their own readings using scientific monitoring equipment, cameras, GPS data receivers, and entering data into the nQuire software run locally on the netbooks. The year group was divided in two and students participated in one of two successive days.

Students returned to their classroom to analyse their data, which had been uploaded by the research team to a central webserver allowing access from any internet connected computer, and write up their reports. The netbooks could connect via the school's wireless network to the internet, though were not connected to the school's shared file store. Students worked on their reports as homework, and some borrowed netbooks to help with this task. The 2008 collaboration was deemed to be a success by the teachers, and as a result they asked the research team to support a similar activity in 2009. Lessons were learnt from the 2008 trial and incremental improvements were made although generally the system and its operationalisation remained the same.

As well as considering pedagogical and software challenges, the practical management and technical support of a large number of netbooks was a significant challenge. In 2008, twelve laptops were supported; one issued per group of students for fieldwork and then issued to individual students to support writing up of reports outside the classroom. The following year (2009) thirty laptops were supported by the research team. Fieldwork was still based around one laptop per group of students, but as the PI project had now acquired more laptops a greater number were issued to students for home use during the reporting period.

Students worked in groups, with each member initially taking responsibility for one role and one piece of equipment (netbook, GPS receiver, camera or science data logger and sensors). Students were able to manage use of the netbooks with very little support during the data collection, successfully entering data at each measurement location (see Figure 1 for sample data entry screen). Working 'on the move' was greatly facilitated by the speed of the start-up and suspend/resume sequences enabled by the netbooks' solid state drives (approximately 20 seconds from switched off, and 5 seconds from sleep, to full operation). This compared to the boot up time on Windows laptops with conventional hard drives of over a minute, which might have led to disruption and lost teaching time (Cramer, Beauregard and Sharma 2009). Some students noted that the keyboards were a little small and the trackpad was received with varying degrees of enthusiasm, though no students failed to enter data.

[Figure 1 here]

Screen brightness was generally acceptable, with students moving to locations where they had the best visibility and again in some cases using friends to shield the screen from the sun. The battery life of the netbooks was sufficient for most student groups when they followed instructions to close the lids and save battery life between data collection episodes. Overall, the netbooks performed very well in the field and proved themselves to be robust, in part due to the solid state drive tolerating movement during use. Only one had to be taken out of service, after being dropped, though it continued to function and data could be retrieved. This allowed the group in question to have their data transferred to a spare netbook and continue their data collection with only a few minutes delay.

A critical task at the end of the first day's fieldwork for the research team was to upload student data from each netbook, charge batteries, and reset the netbooks back to their original state. The Asus netbook's USB and Ethernet ports allowed rapid file transfer of files onto the central server, and the resetting of software could be undertaken on multiple machines using pen drives. This was still a time consuming process and the time and space needed to manage multiple machines for large scale fieldwork should not be underestimated (Vahey and Crawford 2002).

Data analysis and report writing was carried out by the students in the school's ICT suites, with one student per desktop PC. Initial analysis was undertaken by students in groups, and then moving to working individually for report writing: an important criterion of the GCSE coursework was that each student's work should be their own, without collaboration. With the nQuire data collection tool accessible on any internet connected computer from a central web server, students were easily able to move between the portable netbooks and larger screen ICT suite desktop PCs.

Students used USB pen drives for transferring work between the netbooks, school PCs, and home computers. It became rapidly apparent that the students' pen drives and home machines were often infected with viruses. The netbooks, being Linux based were unaffected when pen drives harboured Windows viruses. This serendipitous benefit saved us a great deal of time; we later discovered that virus fighting and decontaminating school computers is an ongoing and time consuming task for the IT technicians.

A number of students borrowed netbooks to complete their reports at home using the OpenOffice suite (similar to Microsoft Office), nQuire toolkit and a complete class data set. These home loans proved to be highly popular. Students appropriated these netbooks, using them for other school work, leisure activities, and personalisation (e.g. changing screen savers and downloading software).

Microclimates 2008

The second trial undertaken in Autumn 2008, supported 150 13-14 year old students working with three teachers, investigating microclimates (local climate conditions) around the school grounds. The microclimates inquiry involved students predicting where would be the best location for different types of activity (e.g. having a picnic, flying a kite) and then collecting data at different locations in order to test their prediction. The microclimates investigation was undertaken over two weeks in up to five lessons.

As with the UHI investigations, students worked in groups, and moved between class, group, and individual modes of activity and netbook use (see Figure 2). Classes were either of high ability or mixed ability students. Students worked together to create a group hypothesis. For the higher ability classes, decisions on what to measure and where to take readings were made by the student groups, data was collected by the same groups and analysis and reporting were carried out independently. For the mixed ability classes, decisions on what to measure and where to take readings were taken as a class , data was collected by each group walking around the school grounds as a class, and data analysis and reporting were undertaken individually.

[Figure 2 here]

For this trial, we decided that the netbooks would access the nQuire toolkit from the central webserver, rather than running on each machine, removing the need to upload student data after the data collection activity. This approach relied on internet connectivity at all times. We worked with the school IT technicians, extending the school network to provide coverage around the school grounds.

The first two fieldwork sessions worked reasonably well, though we found that the signal dropping out caused some delays with students' data entry. On framing this issue to the students as being similar to the varying signal reception strength experienced by mobile phones, we found that they accepted the technical limitation and developed their own strategies for coping, ranging from writing down data in notebooks for later data entry to moving around until they found a place in the school grounds with a strong enough signal strength. This issue was further complicated during the trials when the school experienced a series of power cuts which caused the school's network equipment to fail. We resolved this problem by having one of the research team walking round, with the students, carrying a laptop running a mirror of the web server, connected to a battery powered Wi-Fi point. Students could connect to this local server, and the research team uploaded the data to the central server after each fieldwork session.

Teachers had anticipated students would analyse their data and write their reports using the school ICT suites. The power cuts around the school meant that this was not always possible. Using a local copy of the server running on a laptop, students could access their data and use the OpenOffice tools on the netbooks to write up their reports. One unexpected outcome of this fallback plan was that one of the teachers reported her students behaviour improved and they were more engaged when working on the netbooks in her classroom than on school machines in the ICT suites. When power was returned to the school, she asked if the students could continue to write their reports using the netbooks in her classroom rather than returning to the ICT suites.

Sustainability Squad 2009

The fourth trial focussed on less formal learning, supporting an after school club run by the Geography teachers. This was named the 'Sustainability Squad', and took the food production cycle and food sustainability as its themes. Run in the Autumn 2009 term by three teachers, the club had a varying attendance of between 10 and 30 students at each one hour weekly session. The after school club was much more informal than previous investigations as attendance was voluntary and the inquiries were devised by the students with support from their teachers.

All participating students were issued with a netbook until the end of the term (approximately ten weeks) and were responsible for them. Again, the netbooks connected to nQuire on a central web server. However, this meant that while the research team could be confident of the netbooks connecting in school, students would have to manage their home connection themselves, so a help guide was provided. Supporting home connectivity is often problematic: as well as making sure the student knows the correct procedures, the home network may not be set up to accept new connections and, even if it is, parents may not know passwords, or may not be willing to allow their children to access the internet on a machine outside parental control (e.g. Kerawalla and Crook 2002). However, after a few weeks the majority of students were connecting successfully at home and at school.

Work was mostly group based, with students forming friendship based groups at the beginning of their inquiries. To familiarise students with the netbooks and other tools including the nQuire software, two small inquiries were set up: a student poll and family member interview. These proved to be of limited success, as the students showed a degree of reluctance to interview family and friends. The main inquiries required students to investigate a food product, research its lifecycle from growth to disposal, and undertake a related scientific experiment. All groups decided on studying packaging and decomposition, and ran experiments to monitor the rate of decay of a selected food product.

The majority of students used the netbooks for reporting on their findings, generated from conducting web searches for information related to the sustainability of food, and for collecting quantitative data from their home inquiries into the decomposition of food. Students also used school computers during club time, and home computers. The students appeared to enjoy working on 'their' computers and used them to complete homework and undertake their own social activities. We had set up the netbook web browsers with the nQuire toolkit as the default home page to simplify access, but many students changed this to their preferred home page, for example YouTube or free games sites.

Students downloaded free Windows-based games and were disappointed that they would not run on the Linux netbooks. This can also be seen as a compliment to the design of the netbook's user interface, as students had assumed it was a minor variation on the familiar Windows operating system rather than a different operating system altogether. Students had adopted it with very little training and rapidly became accustomed to the different interface.

Discussion

Having studied a broad range of students undertaking authentic investigations using netbooks, three themes related to open learning are emerging, namely: netbooks used as a ubiquitous single device across activities and places; students' adoption and appropriation; and organisation and management. The following discussion considers each theme in turn.

Netbooks used as a ubiquitous single device across activities and places

Supporting these investigations has meant enabling students to progress their inquiries and cumulate knowledge while moving across activities and places. Like many open learners, our students move between classroom, fieldwork sites, and home, in formal and informal learning environments, and undertake a range of tasks including planning, researching, data collecting and report writing. We had identified that PDA and phone format mobile devices were limited in their functionalities and were keen to investigate if a single device, the netbook, was capable of supporting all aspects of an investigation.

The Asus Eee PC netbooks appear to have performed ‘well enough’ with students able to carry out all tasks requested of them within their inquiries using these devices. During planning students needed a device they could read significant volumes of text on, type in hypotheses, and make selections. Group decisions were made so the device had to be passed between students. Fieldwork required fast start up times from ‘sleep’, short text entry, portability, use in bright sunlight and rain, and shared viewing of the screen for decision making. Data analysis and report writing required viewing multiple screens, high volume text entry, and use of word processing and spreadsheet tools that were compatible with the school computers. Students have noted that the small size of the netbooks makes them suitable for carrying between home and school, and have used them to complete their investigations and other activities at home.

Students’ adoption and appropriation

A common concern when introducing new technologies to learners is that these will be unfamiliar, complex, and get in the way of learning (e.g. Cramer, Beauregard and Sharma 2009). However, the students adopted the netbooks quickly. Immediately after issuing the netbooks, we observed students exploring their functionalities, for example finding and using the built-in video camera, sound recorder and games. Roschelle (2003) found that open access to the Internet and other applications can be problematic in classrooms, as it enables disruptive behaviour and draws attention away from the teacher. Similarly, our students’ use of the netbooks had to be managed by the teachers.

Home loans were very popular, and students used the netbooks for other schoolwork and for personal social use. The installed OpenOffice suite is similar to the Microsoft Office suite that students use at school, and we found evidence of students using this to complete other school homework. The built in Wi-Fi, and USB ports mean that students could transfer work between easily between the netbooks and home and school computers. Many students personalised their loaned netbook, for example by modifying the background wallpaper, and resetting the web browser home page to their own favourite site. Students would help their peers to overcome difficulties, and we noted students problem solving for each other as well as coming to the research team when they needed technical support, for example to achieve network connectivity at home.

Organisation and management

Management of mobile devices is time consuming and this is a critical aspect of ensuring the long term sustainability and incorporation of these devices within any learning environment (Vahey and Crawford 2002). It involves both social and behavioural tasks (communicating appropriate use standards to students, reminding them to charge batteries, collecting in netbooks after loaning), as well as technical tasks (setting up netbooks for student use, uploading data to the central web server, repairing or replacing damaged netbooks). Using identical hardware configured in an identical manner for all participants (students, teachers, and research staff) simplifies the process, and allows for rapid swapping of replacement equipment if any problems arise.

Directing students to undertake investigations by connecting to a central webserver reduced the set up and maintenance time required on the individual netbooks, but required ubiquitous and reliable network connectivity. The reality is that this can be challenging to achieve and maintain (Roschelle 2003). In Oakgrove School, the IT technicians were happy to grant network access to the netbooks so the students could browse the internet, but on some occasions (e.g. UHI fieldwork when walking across two towns) we could not assure connectivity and had to configure the netbooks to run the nQuire toolkit on each machine (‘locally’). The majority, but not all students could connect at home and if connectivity was an essential part of an investigation then more time would have to be spent achieving this goal. The ability to run software locally on mobile devices (implying suitable processor power and memory size) and have a manageable synchronisation strategy is important.

Conclusion

This work has been undertaken in the context of secondary school inquiry projects, however, the findings regarding the educational affordances of the netbooks can be more generally applied to other open learning contexts. Even before the ubiquitous availability of computers it was recognised that many distance learning students at the Open University, juggling work, study and family life, sought to make use of their limited time by working across different contexts and on the move such as on trains, buses or in lunchbreaks at work (Jones, Kirkup, and Kirkwood 1992). Portable devices, such as netbooks can support long established practices and greatly enhance the resources that students can access in different locations.

The Open University have employed netbooks to enable mobility impaired students to participate in undergraduate geology fieldtrips, connecting a student in a roadside car to a roving geologist on the mountainside connected by Wi-Fi (Gaved, McCann, and Valentine 2006). Netbooks were ideal as lightweight, portable devices for use in the field, capable of running multiple software programs to transmit video and audio and store high-resolution images, operating on battery power for long periods in all weathers, and could then be used to review work and aid report writing and collaboration on return to field study centres or used later in the students' own time. Netbooks have been used as mobile digital guides for museums, (Uotila et al. 2009) enriching informal learning directed by participants (school aged students, and enable trainee surgeons to undertake blended learning between tasks in the workplace (Larvin 2009).

We have investigated the use of netbooks as a single device to support a range of learning activities associated with mobile learners. An alternate approach would be to use a separate optimal device for each activity, however, we have established that portability and device management are critical aspects to ensure the adoption and sustainability of mobile learning. A single 'good enough' device, therefore, is more desirable. The current generation of netbooks deliver a wide set of tools in a portable form. Of these, our students make extensive use of the word processing, spreadsheet, presentation, web browsing, sound and video applications. For the set of activities we needed to support in the PI project, the netbook format is currently the most suitable. Distance learning institutions should consider the affordances and features of netbooks when recommending hardware to students, Sharples (2000) suggested some principles for selecting ideal tools for lifelong learning. Extending upon these, we have found netbooks to exhibit the following desirable characteristics:

- Highly portable: enabling students to work "anytime, anywhere" (Waycott 2004)
- Single, flexible device: offering the ability to work across a wide range of tasks and activities
- Suitable input devices: the full keyboard, trackpad, and ability to plug in a mouse enabled students to complete the full range of activities across inquiries as well as data entry during fieldwork
- Functional screen: large enough to view web pages and capable of supporting report writing, bright enough for work in daylight and rugged enough to cope with fieldwork and use on the move
- Networked: allowing students to connect to remote servers and online resources
- Intuitive: similar to the tools already known to students

In our ongoing work we are seeking to engage school teachers and IT technicians further in the management of the netbooks to understand how well they can be realistically integrated into school practice. We are also interested in comparing the affordances of netbooks against the new generation of smart phones (e.g. iPhone, HTC) and tablets (e.g. iPad, Toshiba) and it is clear a range of highly portable yet powerful devices have arrived and will affect how learners study across contexts and environments in the near future.

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Tables and captions to illustrations

Table 1. An extract of the table used for comparing mobile devices.

Format	**Model**	**Operating System**	**Input device**	**Screen size**	**Web client**	**Web server**
PDA	HP iPAQ hw6915	Windows Mobile 5.0	Touch sensitive screen and keyboard	3”	Microsoft Pocket Internet Explorer	Limited window s mobile server
Phone	iPhone	iPhone OS 1	Touch sensitive screen	3.5”	Safari Web browser	No
	Nokia N800	Internet Tablet OS 2007 Linux	Touch sensitive screen and 5-button D-Pad	4.1”	MicroB Web browser	Limited apache server
	HTC Qtek 9100	Microsoft Windows PocketPC	Touch sensitive screen and sliding keyboard	2.8”	Microsoft Pocket Internet Explorer	Chili server
Netbook	Asus Eee PC 701	Xandros Linux	Full keyboard	7”	Any Linux browser	Any Linux server

Figures

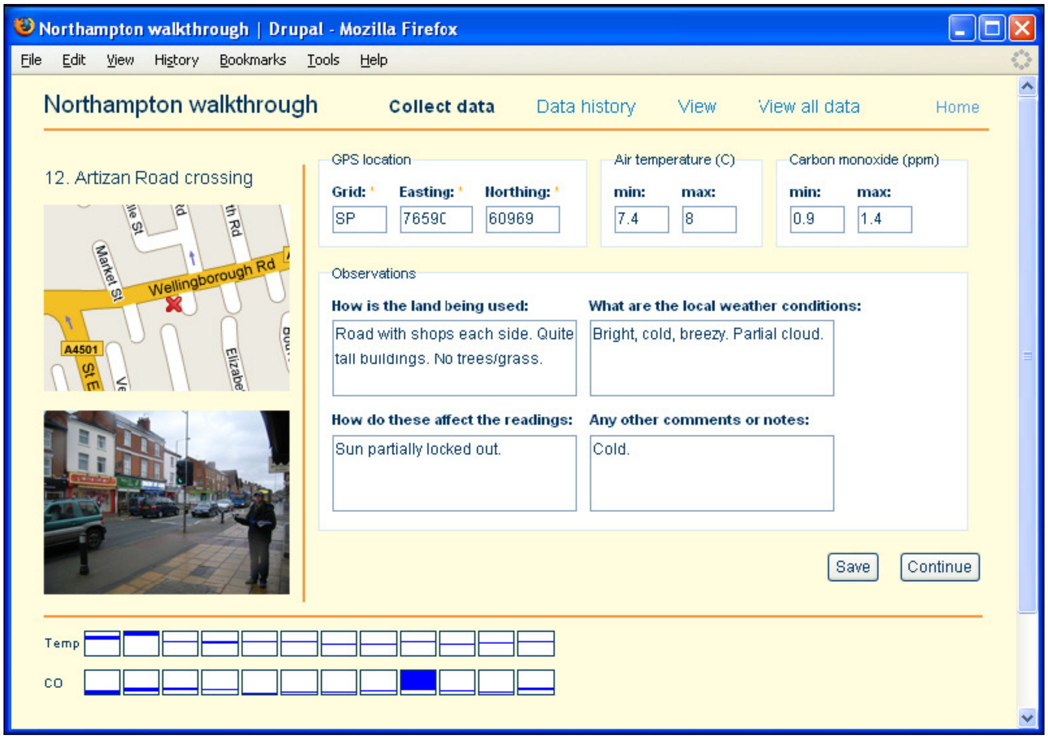

Figure 1. Sample data entry screen for UHI08 displayed on Asus Eee PC netbook.

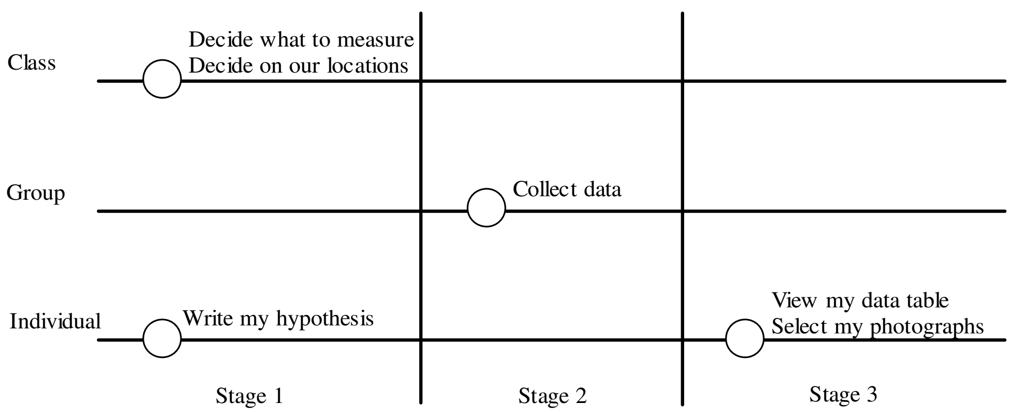

Figure 2. Activities at the individual, group and class levels within the microclimates inquiry (from Mulholland et al., 2009).