Supporting location-based inquiry learning across school, field and home contexts

Conference or Workshop Item

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ABSTRACT
Here we explore how technology can be applied to support inquiry learning spanning a range of contexts. The development process of a location-based inquiry learning toolset is presented for a secondary school GCSE Geography project. The design framework used and the process of participatory development is discussed with regard to the co-development of the activities and tools involved in an inquiry project. The lessons learned relate to the formation of a motivational context for the inquiry; the role of personal data collection in the field; the use of bridging representations across field and classroom activities; and the development of flexible, re-usable tools to support and bridge sequences of activities.

Author Keywords
Inquiry learning; motivational context; sequencing activities; investigation tools; process support; participatory design; incremental and iterative development.

INTRODUCTION

This paper describes the development of a location-based inquiry learning toolset to support an eight week GCSE Geography project, which has been completed by 78 students in a UK secondary school. The paper discusses the process with regard to the design of technology-supported inquiry activities, and the use of mobile and web technologies to bridge learning contexts. This work was carried out as part of the Personal Inquiry (PI) project, a three year Technology Enhanced Learning project funded by the UK's Teaching and Learning Research Programme. The aim of the project is to understand how effective learning can be enabled with technology between formal and informal settings, such as in school, on field trips and at home.

One of the challenges of educational fieldwork is to incorporate the skills and knowledge acquired in the field with those in the classroom and other learning contexts. To address this problem we are exploring the potential of mobile technologies that can be used persistently across these contexts and the application of a scripting approach to inquiry learning to help direct the students' activities towards the attainment of their learning objectives. A five stage process of scientific inquiry was used in this case, consisting of the question, methodology, data collection, analysis and conclusions. Extensive use of ICT was made across all stages of the inquiry: the students used the web to research the inquiry topic, and a range of Office applications were used to write up each stage of the project in the form of a report. A web-based application was developed to support the data collection and analysis stages of the inquiry. An Ultra Mobile Personal Computer (UMPC) was used to record data during the data collection activity on a one-day fieldtrip, and these were also available for loan to the students for the remainder of the project. Through the combined use of the web-based application, the loan computers and a set of USB memory sticks, the students were able to access their data and work on their project in a consistent way, both at school and at home.

BACKGROUND

Inquiry learning can be an effective form of tuition for acquiring intuitive, deep, conceptual knowledge (de Jong, 2006). While recognising that a balanced form of instruction is needed, inquiry learning across the school curriculum is becoming a widely recommended approach. For example, in a recent report on the standards of Geography education in primary and secondary schools in the UK, the government's educational standards group noted that "enquiry-based fieldwork sharpens and deepens learners' understanding of geography and the progressive development of geographical skills, both in situ and in the lessons in school related to it" (Ofsted, 2008, p. 34).

Location-based inquiry learning across school, field and home contexts is a form of learning in which the learner is mobile and therefore has a pragmatic need for appropriate technology to support their learning activities (Sharples, Taylor, & Vavoula, 2007). A range of research projects have explored the potential of mobile technologies for supporting learning (for a series of case studies, see Naismith, Lonsdale, Vavoula, & Sharples, 2004). Of direct relevance to this work are the Ambient Wood (Rogers et al., 2004), Mobilearn (O'Malley et al., 2003) and Participate (http://www.participateschools.co.uk last accessed April 2008) projects. Ambient Wood investigated the design, delivery and interaction of digital information for learning about ecology outdoors, thereby providing an applicable set of guidelines for the PI project. Mobilearn was concerned with the development of context-aware mobile devices, for delivering content and services to mobile learners. Finally, the Participate project is exploring the three strands of schools, community and games for developing web-based support for school education. Through collaborating with schools this project is developing a series of collaborative mobile and web technologies for use in schools.

APPROACH

We have adopted a participatory design approach on the PI project. Working in partnership with the teachers we have developed a set of learning activities and support tools around a specific topic. Recommendations and feedback were also given periodically during the development process by our collaborators at ScienceScope, a company involved in producing sensing and data logging equipment for science education.

In early meetings we explained the goals of the project and the type of technologies that we were interested in exploring. In discussing potential topics, one of the teachers proposed to investigate urban heat islands and suggested that they could run an inquiry project for the GCSE coursework. Having agreed the context, we then discussed the design of the activities and the supporting tools and resources. A series of paper prototypes and sample datasets were used to inform the development of the activities and tools. In the course of developing our ideas we decided to collect a set of temperature and environmental data across Milton Keynes. From the advice of ScienceScope we measured air temperature, carbon monoxide, wind speed and infrared irradiance. In the course of developing the activity we extended the fieldwork to cover two towns, in order to collect a second dataset that would encourage the students to draw comparisons.

The year 10 GCSE Geography group is made up of three classes, and for logistical reasons the three classes were split into two groups, which carried out the same fieldwork activities on two successive days. During their fieldtrip the students worked in self-selected groups. Although the topic and parameters of the inquiry were determined by the teachers, the students were encouraged to develop their hypotheses, research the topic independently, and work individually to analyse the data they collected by relating it to the data collected by other student groups across the two days, and to a further sample dataset collected by the researchers.

The participatory design process began in October 2007. The students started their coursework project in mid February and the submission deadline for their completed reports was at the beginning of April. Through developing support for a specific application we are interested in identifying aspects of the activities and support tools that may generalise and apply to other situations. Within the urban heat island project we were interested in collecting data at specific locations. Therefore, we started from the perspective of developing a support tool for location-based inquiry learning where the location or position of each data point was a defining characteristic of the study. With this in mind we produced a customisable tool that could be tailored to forms of inquiry involving comparisons made across locations.

DESIGN

Five challenges for implementing inquiry-based learning have been identified by Edelson, Gordin and Pea (1999), namely: motivation, accessibility of the investigation technique, background knowledge, management of extended activities, and practical constraints of the learning context. As noted by Edelson et al. (1999) the students' motivation to engage with the activity and the accessibility of the investigation techniques (e.g. their ability to master the techniques and tools used for data collection and analysis) are common challenges also identified in Learner-Centered Design (Soloway, Guzdial, & Hay, 1994). The students' level of background knowledge and their knowledge of investigation techniques needs to be sufficient to provide the basis for a meaningful investigation. The self-regulation required in managing their activities can be difficult for learners without experience in this form of activity (Manlove, Lazonder, & Jong, 2006). Finally, the practical constraints, such as the time and resources available to complete a task or the assessment criteria will affect the nature of the inquiry.

In response to these challenges Edelson et al. (1999) proposed a design framework for technology-supported inquiry learning based on the coordination of the following four interdependent components: "the motivational context, the selection of sequencing activities, the design of investigation tools, and the creation of process supports" (ibid, p. 440). The remainder of this section describes each of these four components for the urban heat island project.

Motivational context

Strategies for selecting a motivational context for learners relate to identifying meaningful, controversial and open issues (Blumenfeld et al., 1991) (Dillenbourg & Schneider, 1995) (Barron et al., 1998). The chosen topic in our case was microclimates and in particular the formation of urban heat islands. This is a metropolitan area that is significantly warmer than its surroundings (http://www.bbc.co.uk/weather/features/understanding/urban_heat_islands.shtml last accessed April 2008). The reported studies of urban heat islands are typically from major cities, such as New York, Tokyo, and London. Explaining this phenomenon requires an understanding of the thermal radiation from buildings; the effect of the geometric properties of buildings on the reflection and absorption of sunlight and cooling by convection due to wind blocking; and the influence of pollution on the radiative properties of the atmosphere. By drawing a comparison between the students' home town of Milton Keynes and Northampton, a neighbouring town, the context became meaningful to the students and engaged a sense of competition. Milton Keynes is particularly interesting to investigate as the central business district has a much lower building density than more traditional towns. This was a legitimate inquiry in that the students (and teachers) did not know if an urban heat island occurred in either of the two towns investigated.

Sequencing activities

Staging and bridging activities are intended to scaffold the students' learning to ensure their knowledge builds through the course of the inquiry process. This component of the design framework specifically targets the challenges of motivation, the accessibility of the investigation technique, and the underpinning of the students' background knowledge. The sequence of the main activities within the project was as follows.

- **Topic introduction**: The students were introduced to the topic of urban heat islands by the teachers in the classroom and explicit links were made to the topics previously covered by the students. It was made clear to the students that this project would be the basis for the GCSE coursework (constituting 25% of their overall mark). [Week 1]
- **Background research and hypothesis**: Primed with a set of relevant websites the students undertook their own research to explore the topic and inform their inquiry. One teacher directed the students to form their own hypothesis from their research, the other gave the students a project title and asked them to research that topic. [Week 1]
- **Methodology specification**: For each type of data they were collecting, the students completed a table stating why they were collecting that data, what equipment they were using, how they intend to check the accuracy and reliability of the data, how often they were collecting the data, and the measurement units used. [Weeks 2 and 3]
- **Student coursework introduction**: Prior to collecting their data the students drafted the introductory section of the coursework report, introducing the topic, their question/hypothesis and methodology. These were submitted to the teachers, who marked them and gave the students feedback. [Weeks 2 and 3]
- **Practice data collection**: In a lesson, a week before they went on the fieldtrip, the students were given an overview of the web application they would use to collect their data (in the classroom), a thirty minute practice session using the equipment (in the school grounds), and a summary relating the data collection tools to their methodology specification (back in the classroom). [Week 3]
- **Data collection fieldtrip**: On a one day fieldtrip the two teachers and half of the students, working in groups of four or five, walked a two mile route (i.e. transect) across the centre of each of the two towns collecting 12 sample data points. Each group of students collected two environmental readings, the air temperature and either carbon monoxide, infrared irradiance, or wind speed. The same fieldtrip activity was carried out on the following day by the remaining half of the students with the same two teachers. [Week 4]
- **Data presentation**: Following the data collection activity the students spent the majority of the remaining lessons in the ICT suite and library working on their coursework report. In the data presentation activity the students checked and corrected their data, and annotated a map of each town with their data values and comments. [Weeks 4, 5 and 6]
- **Data analysis and conclusions**: In the analysis activity the students used Excel to draw bar charts and graphs of the datasets, and discussed these with respect to their hypothesis and methodology. [Weeks 7 and 8]

A study guide produced by one of the teachers (see process supports, below) was provided to support the students throughout the project including maps of the route, background information on the topic, fieldwork guidelines, hints on data analysis and presentation, the coursework assessment criteria, and project deadlines. Based on the background information presented by the teachers in their introduction, and explained in the study guide, the students researched the topic and developed their research question(s) regarding the existence of urban heat islands in each of the two towns. This encouraged the students to articulate their prior knowledge and assumptions, and caused them to reflect on their understanding of the causes of urban heat islands.

Completing the methodology table required the students to explain why they were collecting the different types of data and what they were anticipating their data would show. In addition to being able to access the website resources on the sensors and GPS devices, a 'how to' guide was produced for the available equipment, which illustrated how it could be operated and how the data measures could be interpreted. Having gone through these, the practice data collection session gave the students hands-on practical experience that helped them relate the theoretical properties of urban heat islands with the practical measures and interpretations they could make for themselves in the field.

The fieldtrip was an intense one-day activity that enabled the students to collect their own sensor data and record their comments and pictures of the local environmental influences at each of the sample points across the two towns. In guiding the students through the activity the teachers helped to keep the students focused on the task and encouraged them to explain their interpretation of the data they were collecting at each location. The teachers' prompts also offered opportunities for the students to clarify and revise their understanding of the factors influencing urban heat islands.

Within the data presentation activity the students checked their data and where necessary made typographical or surface-level corrections. Having multiple groups collecting the same type of data across two days enabled the comparison of values and averages that helped the students to identify errors in their data collection. The final two activities (data presentation, and data analysis and conclusions) were completed by the students individually.

Investigation tools

The ICT infrastructure in the school included four ICT suites with sufficient computers for every student in a class, a wireless network providing Internet access throughout the school, and a laptop computer for each teacher that could be connected to an interactive whiteboard in each classroom. From discussions with the teachers and observing the students' working, it was clear that the students were familiar with using web and Office applications. The students had a high level of ICT literacy and made extensive use of Microsoft Office applications and other subject-specific applications in all of their subjects. The students used the web to inform their inquiry and help specify their methodology. Word and Excel were used to complete their coursework report and to support data preparation and analysis activities.

In selecting a set of investigation tools we wanted to identify complementary tools that could be used across the different activities within an inquiry, and could be reused in a range of different types of inquiry. Therefore, rather than selecting a specialist device for data collection in the field we identified devices that could be reused across the activities and learning contexts. The specific devices used to support the data collection activity were an Asus Eee PC 701 (UMPC); a Garmin eTrex GPS Personal Navigator; a ScienceScope DataLogger ML with air temperature, carbon monoxide, wind speed and infrared irradiance sensors; and a Canon PowerShot A460 digital camera. The Eee PC has a distinct advantage over its competitors in that it uses solid-state memory for a hard drive. This enables the machine to boot up in twenty seconds and recover from stand-by within five seconds. By closing the screen on the UMPC between data collection points the students were able to complete the entire fieldtrip using only half of a fully charged battery. The Garmin eTrex GPS navigator brought a further element of authenticity to the activity as these are the preferred types of GPS device used by geographers and geoscientists. The DataLoggers and sensors were used on loan from ScienceScope and were reliable, accurate and robust. Finally, the Canon PowerShot cameras were chosen as a relatively inexpensive easy-to-use digital camera.

A web application was developed to support the data collection and analysis activities. This was intended to help guide the students through the data collection activity, collate the datasets, and provide access to the data in a web page or downloadable as either a comma-separated values (.csv) data file (for analysing the data in a spreadsheet, see Figure 2 left) or as a keyhole markup language (.kml) file (for exploring the dataset using Google Earth, see Figure 2 right). The application was built using Drupal, an open source web content management framework (http://drupal.org last accessed April 2008), which provided a set of modules (i.e. functional components) that could be configured and rapidly extended. Through a succession of screen images and functioning prototypes, with frequent feedback from the teachers, we developed the application in a two week period. The Drupal framework is written in the PHP scripting language, and uses a MySQL database to store the content and configuration data. These are standard applications that run on commonly used platforms (e.g. Mac OS, Windows and Linux).

The choice of a standard operating system running on a powerful mobile device enabled us to develop a single application that could be used locally on the UMPC or on a web server (see Figure 1, left). During data collection the students accessed the web application running on their own UMPC. On the evening of the fieldtrip all of these machines were connected to the Internet and their data was synchronised onto a web server (running the same software), and the collated datasets were immediately available for the students to access from any web browser. During the project, those students that did not have Internet access at home and who wanted to continue working on their coursework were able to borrow a UMPC. With this they could continue to use the collated dataset via the local web application on their UMPC (in an identical way to accessing a remote web server), and analyse their data and write up their coursework report using the OpenOffice applications. Having a single web application that could be used locally or remotely helped us to bridge the classroom, field and home contexts and simplified the development process.

Within the web application, a form was used at each location to prompt the students to collect their data. Figure 1 (right) shows the web form after the completion of the twelfth location in Northampton. The global navigation within the site is shown along the top of each page. The web form is further divided into three sections: the location prompt (on the left), the data entry form (on the right) and a bar chart summarising the data collected at each location (along the bottom). The data entry form asked the students to enter their GPS location, the minimum and maximum data values measured over a one minute period, and to type in their observation notes. The observations area asked the following: how is the land being used, what are the local weather conditions, how do these affect the readings, and any other comments or notes. These prompts were intended to encourage the students to relate the local land use and weather conditions to their data readings. The summary bar chart was intended to confirm the students' actions and help them to see how their dataset was building up during the fieldtrip.

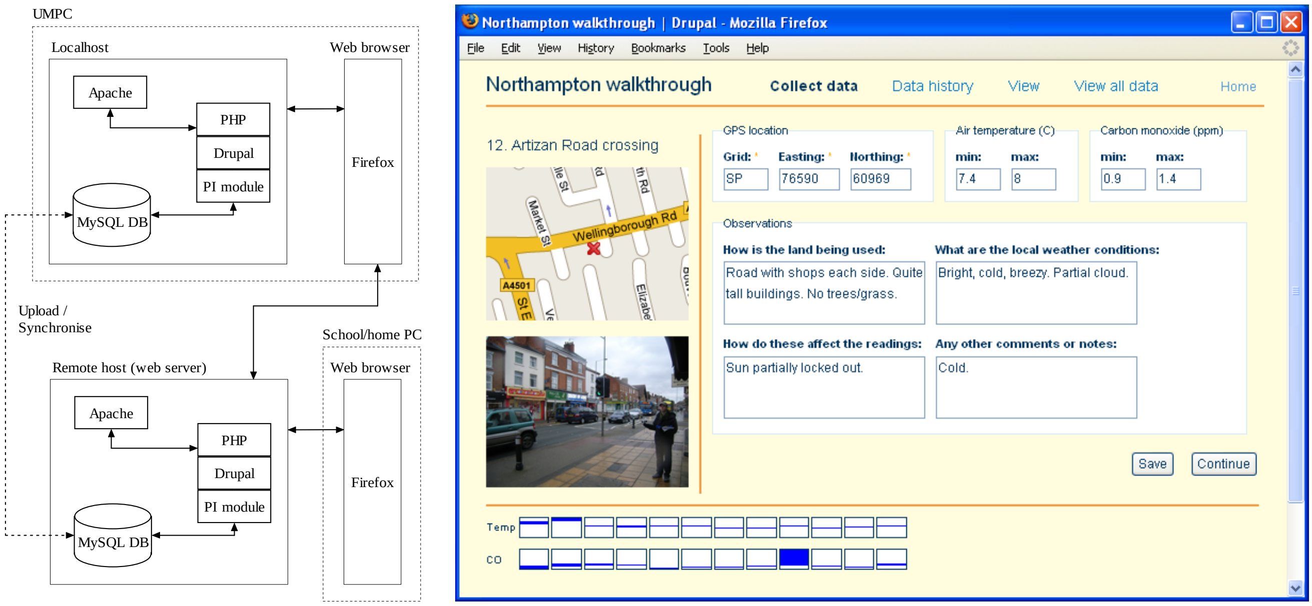

Figure 1. Web application architecture (left) and data collection inferface (right).

The web application also had a 'data history' page that showed the students' dataset and enabled them to edit their entries and download the data either as a data file (.csv) or as a data map (.kml). Like the bar chart on the data entry form, the data history page confirmed the students' progress through the task and enabled them to check and correct their data during the data collection and subsequent activities. The 'view all data' page was available after the data collection activity. This enabled the students to see (and download) the average values for each data type and each groups' individual dataset from the two fieldtrip days, and a dataset from a previous fieldtrip undertaken by the researchers. The screen images shown here are of the students' screens. An additional link was added to the 'data history' page for system administrator accounts that enabled us to upload the data to a pre-specified web server. By dynamically generating data files (csv) and data maps (kml) of the groups' datasets the web application enabled the students to immediately explore their data using standard spreadsheet and Google mapping applications (see Figure 2). Having completed the data collection activity, a copy of the combined dataset from the web server was downloaded onto each of the UMPCs so that any of the students could use any of the machines to work with their data without requiring an Internet connection.

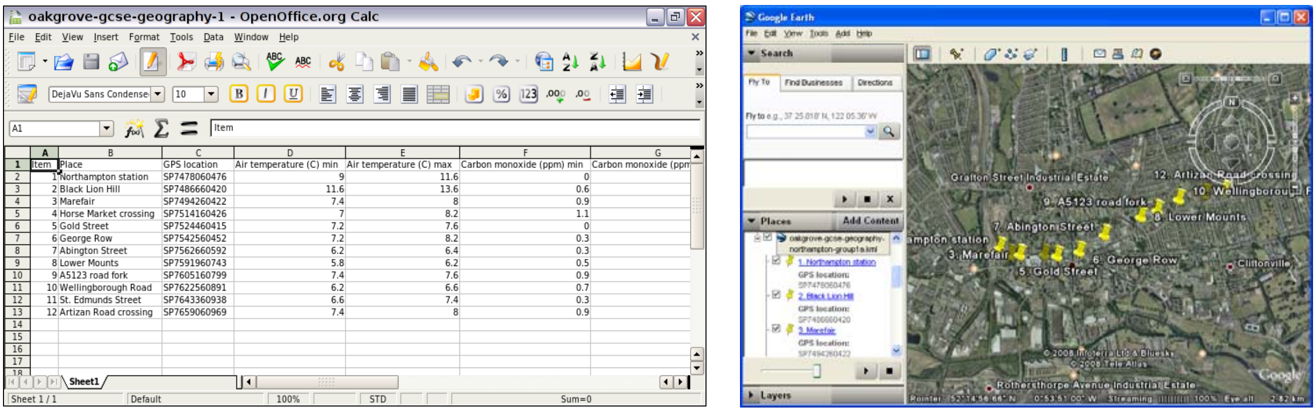

Figure 2. The data file (left - OpenOffice) and data map (right - Google Earth) generated by clicking on the download links available on the 'Data history' and 'View all data' pages.

During the fieldtrip the students were encouraged to take photographs at each location to record the land use and weather conditions. The students took many more photos than we envisaged (although they did not fill the data cards in the cameras). These images were made available to the students on USB memory sticks. The students used these to copy a selection of their photos to their personal folders on the school network, which they used as a reminder of each location and as illustrations in their report.

The students used the web application to access their data during the data presentation and analysis activities. The assessment criteria for the coursework rewarded the students' use of ICT to present tables and charts, and to explain their interpretation of the findings. This limited the level of group discussion within each class and also the level of automation for data presentation and analysis. We could have automatically generated a statistical summary and graphs from the data, but this would have reduced the students' independent work and may have lead to a common set of interpretations by the students.

The web application developed for this project enables groups or individuals to collect data readings and comments for a set of locations. The form and number of data items can be customised for the inquiry (along with the text observation prompts) and varied for each location (if required). Where images or descriptions of the location are available these are displayed in the data collection form to help guide the user. Exporting the dataset using a set of standard file formats enables the user to work with the data using their preferred presentation and analysis tools. However, this does not limit us (or other developers) from creating further investigation tools for these activities in the future should they be required.

Process support

Along with the investigation tools used in the activities, there was a set of supporting resources used in the staging and bridging activities of the project to address the challenges of background knowledge and managing extended activities. Several of the resources were developed independently by the teachers for the students, others were developed collaboratively by the researchers and teachers for the students, and some were produced by the researchers as support materials for the teachers to help them explore the topic and the potential use of the technology.

- **List of potential online resources**: In exploring the topic a list of websites describing the causes and effects of urban heat islands were passed on to the teachers. These were reviewed and a selection of them used to inform the study guide booklet and form a starting point for the students' research. [Produced for the teachers by the researchers]
- **Study guide**: One of the teachers produced a guide for the students, which included an overview of the topic, maps of the routes taken in the fieldtrip, and guidance on the fieldwork and project write-up. [Produced for the students by one of the teachers]
- **How to guides**: A double-sided A4 page was produced for each item of equipment explaining how to operate it and (where appropriate) how to interpret the readings. [Produced for the students by the teachers and researchers]
- **Methodology table**: A double-sided A4 page containing a blank table for the students to complete was produced to help the students clarify their use of the data collection equipment and their intended interpretation of the results. A completed table was also produced and used by the researchers to help guide the 'practice data collection' activity. [Produced for the students by the teachers and researchers]
- **Sample datasets and maps**: Pilot datasets were collected in both towns using the same equipment as the students' prior to their fieldtrip to identify suitable locations, and ensure the data collection activity could be completed in the time available and that the data collected would be appropriate for the intended inquiry. [Produced for the teachers by the researchers]
- **Data spreadsheets and charts**: In addition to generating pilot datasets and maps, spreadsheets and charts of the fieldtrip data were compiled and made available for the teachers to help them guide the students' data presentation and analysis activities. [Produced for the teachers by the researchers]
- **Example analysis graphs**: One of the teachers created an example graph of some of the data and showed it to the students at the start of their data analysis activity. The teacher used the example to illustrate the process of data analysis and explained how the students could go about interpreting their data. [Produced by one of the teachers for the students]
- **Flickr website**: The photographs taken during the pilot data collection activities were put on a public flickr website during the course of the design process (http://www.flickr.com/photos/22059888@N04/ last accessed April 2008). These images were also made available to the students to ensure they had at least one photograph of each location. [Produced for the students by the researchers and teachers]

Several of the above examples were produced as collaboration artefacts that helped facilitate the co-design of the tools and activities by the teachers and researchers. The same set of process supports may not be necessary in other inquiry projects, but the role they played in encouraging and recognising the participation of the collaborators was important in this case. The study guide, how to guides, methodology table, and example graphs are process supports that directly helped the students in the inquiry process and are typical of support materials created by teachers for their students.

DISCUSSION

The following lessons learned can be drawn from the work presented here.

Motivational context

Authentic inquiry: Investigating the existence of urban heat islands in Milton Keynes and Northampton was a motivational form of inquiry because the characteristics of Milton Keynes (a new town) are very different to more established towns (such as Northampton). Therefore, the students were not repeating a previous study where the result was already known or even replicating the findings from directly comparable towns. Having contacted experts in urban geography and city planning, we were unable to find any such studies that had been completed in either town.

Guaranteed outcomes and legitimate inquiry: In preparing for the students' inquiry project the sample datasets demonstrated the suitability of the equipment and the types of measure being taken. They could also be used as a back-up dataset if the fieldtrip had to be abandoned due to unforseen problems, such as extreme weather conditions. Given that this project was to form the basis of the students' coursework having a guaranteeable outcome was necessary. However, as well as providing a 'safety-net' the additional dataset added legitimacy to the students' data as they were able to explain the similarities and differences across the datasets collected on three different days.

Sequencing activities

Hands-on practice of the experimental procedure: Having used the equipment in the school grounds to collect three sets of data during the week before the fieldtrip, the students were familiar with the equipment and their experimental procedure. As a result they were able to concentrate on collecting and interpreting their data without being overwhelmed with the operation of the equipment.

Manual versus automatic data collection: Both the Garmin GPS navigator and ScienceScope DataLogger could be set to automatically collect data traces, which would be comparable to the numerical data collected manually by the students. However, it was decided that the process of reading the data from the devices and typing it into the web form should be part of fieldwork as this would help the students attend to the data readings and how these relate to the observations they were making regarding the land use and weather conditions in each location. If the role of the students had just been to transport the recording sensors around the twelve locations in each town, it was thought that they may have been less likely to relate the data readings at each location to the local land use and weather conditions. Furthermore, giving each group member a specific device (i.e. a UMPC, GPS navigator, DataLogger, or digital camera) meant they had a clear role and responsibility.

Investigation tools

Agile tool development: As noted above, our approach to designing the inquiry activities and tools relied on the participation of the teachers involved. Through developing a series of (literally throw-away) paper prototype designs we could explore a broad range of design solutions. As the design became more focused we moved to functional prototypes and, because these were web-based applications, the teachers could easily check them and give us quick feedback via email or on the telephone. Using a content management framework enabled us to rapidly develop and revise functional prototypes, which greatly facilitated the co-development of the activities and tools. As the activities were revised the tools could be updated within a few hours and the next prototype made available for testing. Through a series of inquiry projects (such as the one presented here) undertaken as part of the PI project, it is our intention to produce a set of inquiry tools through a process of iterative and incremental development that can be used to investigate a range of topics. The underlying assumption of this approach is that through developing tools and activities across a range of inquiries we will be in an informed position to identify the characteristics and patterns from which a general inquiry toolset could emerge.

Collating and presenting shared data: The web application automatically collated the datasets to create an average set of data values across the groups on each fieldtrip. Through comparing their group data to the average data values, the groups were further supported in identifying possible mistakes in their data collection process. In a few cases the students had not entered the decimal point in a data value resulting in a significant difference between the group and average value. Another type of mistake, that this representation helped to identify, was the case where some of the students had switched the minimum and maximum values for negative data readings. Although both of these types of mistake were easy to correct, it was the average data values that highlighted their occurrence. For the GPS data any mistakes were identified once the students opened their dataset in Google Earth. As the GPS readings were recorded using Ordinance Survey grid units (OSGB36) any mistake in the easting and northing measurements resulted in the location being offset (up to 99,999 meters) either horizontally (east-west) or vertically (north-south) on the screen.

Export to common file formats: The decision to export the datasets using common file formats meant that the teachers and students were not constrained to use a particular presentation or analysis tool. In our case, it was of interest to see how the teachers and students used their chosen tools, and which forms of data representation they preferred. We can now draw on the experiences captured in this trial to inform the design of tools and activities in the future.

Process supports

Bridging representations: We found that the maps of the two towns were useful bridging representations. These first appeared in the study guide created by one of the teachers as a map of each town with markers representing the data collection points. Based on this, we added them to the interface of the web application by putting the same town maps on the home page for each part of the data collection activity. We also added zoomed map sections to illustrate each location alongside the data entry form. Maps are an obvious form of representation for location-based data, but using this common form across the methodology, data collection, presentation and analysis activities helped bridge the overall inquiry process.

Representations mixing the abstract and concrete: In presenting their work in a report the students used representations that mixed the abstract and concrete. One example of this was the annotation of their charts with photographs, explanatory text and data values; another was the annotation of the two town maps with photographs, charts, explanatory text, and data values. Both of these mixed representations explicitly related the abstract data values and graphs to the more concrete map positions, observations and photographs at each location.

FUTURE WORK

This paper presents the first in a series of trials to be carried out as part of the PI project. During the eight weeks of the project the Geography lessons were recorded (including the two fieldtrips), capturing the work of four groups of students. This has produced over fifty hours of video data which will be reviewed and analysed over the subsequent months. Copies of the students' work will also be available for analysis. A Technology Awareness questionnaire was completed by the observed students before the project began and will be completed again after they finish their coursework. The teachers and the two student groups were interviewed before they began the project and will be interviewed again when it is completed. The evaluation of the inquiry project and the process that produced it will be the focus of our ongoing work.

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