

The Public Understanding of Environmental e-Science and SENSE Projects: e-Science Learning Activities

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Abstract

E-Science has the potential to transform school science by enabling learners, teachers and research scientists to engage together in authentic scientific enquiry, collaboration and learning. Two related e-Science projects were conducted between 2003 and 2005 that focussed on ways to bring e-Science into secondary science teaching and learning, and take active, hands-on learning beyond the classroom into the local environment. The “Public Understanding of Environmental e-Science” project and the “Schools E-Science Network for the Study of Environmental science” (SENSE) project were exploratory studies probing potential methods to incorporate e-Science into science learning. The hands-on learning activities were based around the science of studying Antarctic lakes, carbon monoxide monitoring in air pollution, and full scientific lifecycle skills. In this report we provide the details of the studies and refer the reader to other published work for further details about the analyses we conducted on the projects’ data.

Keywords

e-Science, distributed learning environments, hands-on data collection, webquest, full scientific lifecycle, outdoor science, collaboration.

Introduction

The UK National e-Science Centre (NeSC) website describes e-Science as follows:

"e-Science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it. e-Science will change the dynamic of the way science is undertaken." From NeSC¹

We believe e-Science also has the potential to change the way science is learnt. A recent review of e-Science in education (Woodgate & Stanton Fraser, 2005) arrives at the following definition:

“The use of ICT in education, to enable local and remote communication and collaboration on scientific topics and with scientific data” (p15 Woodgate & Stanton Fraser, 2005).

¹ From the UK National e-Science Centre definition of e-Science <<http://www.nesc.ac.uk/nesc/define.html>>

Using these ideas, we ran 21 e-Science learning sessions with children and teachers as part of the two projects in 2004. Both projects used environmental e-Science research supported by the Equator research group's e-Science theme² to source: devices, expert scientists and material for use in the sessions.

The purpose of this report is to present together the learning activities from the Public Understanding³ and SENSE⁴ projects. Firstly, we briefly introduce the research context for our e-Science, remote sensing and urban pollution monitoring work. Then we describe the Public Understanding e-science sessions and SENSE e-science sessions. It is beyond the scope of this report to discuss and develop results and analyse findings, for this the reader is referred to other publications we have written with our collaborators (Underwood et al., 2004; Tallyn et al., 2004; Stanton Fraser et al., 2005; Avramides et al., 2005; Smith et al., 2005; Smith et al., 2006).

Equator Vision for Ubiquitous e-Science

The Equator (Equator, 2004) "Advanced Grid Interfaces for Environmental Science in the Lab and in the Field" e-Science projects demonstrated how data, captured from remote sensors on an Antarctic lake (Benford et al, 2003) and mobile CO sensors deployed in an urban environment (Steed et al, 2003) can be integrated with other data sources and accessed on a global scale. This access enables scientists to visualize, manipulate and share the data from any location. We refer to these two e-Science research activities as the *Antarctic remote sensing project* and the *Urban CO monitoring project*. The Antarctic remote sensing project was a collaboration between the Australian Antarctic Division, Equator and the UK e-Science programme. This project concentrated on developing and extending Grid infrastructure for access 'in the field' by supporting the study of Antarctic lakes. This involved researchers setting up a monitoring device on an Antarctic Lake, which then made the information it collected available on the GRID. The Urban CO monitoring project built a number of mobile sensing systems that give a broader and denser picture of how pollution affects urban spaces and the people within them. Both projects explored the ways in which diverse mobile and distributed sensors and devices, connected to a large scale distributed computing infrastructure, can support new forms of scientific enquiry.

This vision of e-Science emphasises the need for scientists to effectively collaborate, manipulate and share data from any location e.g. in the lab or in the field; and also the need to enhance current labour-intensive approaches to observation and measurement with automated capture and sensing technologies that deliver more detailed, timely and continuous data. Data recipients and users may be local to the equipment or remote.

Extending the Vision: Schools as e-Science participants

We believe e-Science in schools could support mutually beneficial collaborations between 'real' science research projects and school scientists on a large scale. Such collaborations would have benefits for learner-engagement, teacher interaction with domain experts (continuous training) and scientist involvement in wider science community projects. Indeed, there are many examples of science research projects that do benefit from public input and

² Equator Research Group e-Science Theme <http://www.equator.ac.uk/index.php/articles/c66/>

³ Public Understanding of e-Science project funded as part of Equator

⁴ SENSE project funded by JISC

that are in some ways similar to what we are suggesting (e.g. The Woodlice Survey⁵, Big Bug Count⁶). Such projects typically encourage public participation to collect large amounts of data over wide geographical regions and use web-based interfaces to retrieve the data. With the e-Science sessions for school children we attempted to stimulate and support researchers and the public's active involvement not just in data collection but also in its analysis as well as reflection on both the scientific activity itself and at a meta level on the potential use of sophisticated devices and software to support scientific research and learning. We also wanted to provide a sense of direct and active collaboration between real environmental scientists, learners and teachers by using both live and asynchronous communication tools to put participants in direct contact.

The e-Science Learning Sessions: Public Understanding and SENSE Projects

Our first e-Science learning sessions were run as part of our Public Understanding for Environmental e-Science project. In these sessions, we made use of existing 'school science labs' for gifted and talented children, which generally take place in a science laboratory at our university. These 'science labs' are for groups of between 8 and 14 children (14-16 years old) who are in the top ten percent for science ability at two local schools. As these children are already performing well in terms of curriculum requirements there is less pressure to fit work tightly to the curriculum and consequently opportunities exist to try out more experimental learning activities. The broad objectives for these sessions are to engage and challenge the learners. We worked with the organisers and teachers of these sessions to design an e-Science specific session that we ran with 5 groups.

The second set of e-Science sessions took place after we had completed the Public Understanding sessions and formed part of the SENSE project which had the specific objective of exploring the links between e-Science and e-Learning in the classroom. These sessions ran in schools during science class time and were developed in collaboration with the science teachers to fit the needs of the science curriculum. Overall, the Public Understanding and SENSE sessions involved 62 children and 4 teachers from 4 schools in two distinct contexts. Table 1 summarises these sessions.

Table 1. Summary of e-Science Sessions

Session Type	Total number of Learner Participants	Number of Sessions and duration	Age (yrs)	Participants per session	Subject Matter
Public Understanding of Environmental Science	43 (Gifted and Talented) learners	Same 3 hour session repeated 5 times with different participants	14-16	8-14	Part 1 of Session Antarctic Remote Sensing
					Part 2 of Session Urban CO Monitoring in University locality
SENSE	19 learners	Series of 8 sessions involving same participants, and run separately as two halves of class	13-14	8 and 11	Urban CO Monitoring in school locality

⁵ <http://www.nhm.ac.uk/interactive/woodlice/index.html>

⁶ <http://www.rspb.org.uk/bugcount/index.asp>

Public Understanding e-Science Sessions

We ran five, three-hour Public Understanding e-Science sessions, with activities taking place both in a laboratory and around the campus at our university. Between 8 and 14 children aged from 14 to 16, 1 or 2 teachers and 2 or 3 educational researchers participated in each session, with from 1 to 4 science experts involved remotely through real-time messaging. A total of 43 children and four teachers took part in the sessions. Each session consisted of two periods of one and a half hours with a 15-minute break between periods. The first period focused on the *Antarctic remote sensing project* described above. The second period focussed on the *Urban CO monitoring project* also described above.

Public Understanding e-Science Session Objectives

The principle aim for the Public Understanding sessions was to provide learners with a hands-on e-Science like experience. Specifically, we challenged participants to find out about the Equator e-Science *Antarctic remote sensing* and *Urban CO monitoring* projects, think about the science these projects were trying to do, and to decide for themselves what e-Science might be. We then prompted participants to reflect on how modern technology (communications and data logging and visualisation software, remote and handheld sensors, GPS etc...) might more generally be employed in scientific research and their own learning. To support this process, we developed structured research tasks using web-based materials (Underwood et al., 2003) and practical data collection and analysis tasks using handheld devices and visualisation software. An overview of the sessions and activities is presented below, for more detail see Underwood et al. (2004).

Public Understanding Session Structure and Activities

1st Period – Antarctic Remote Sensing

- *Contextualisation:* We showed learners a series of images (e.g. figure 1) relating to the *Antarctic remote sensing project* and the *Urban CO monitoring project* and prompted them to think about what these images showed, then arrange them into two groups and discuss how the images in each group might relate to each other. We then challenged them to find out what they could about these research projects online using a structured “Webquest” like activity⁷. Throughout this process we encouraged learners to formulate and write down questions they would like to ask the researchers involved in these projects.



Figure 1. What is it? What does it do? Where is it? Why is it there?

⁷ e-Science Webquest <<http://www.informatics.susx.ac.uk/users/joshuau/esci/investigation1/frameset.htm>>

- *Communication with Remote Experts:* We then used MSN Messenger for live text chat with ‘globally distributed researchers’ located in the Antarctic, Nottingham, Australia and London. In each session we contacted from 1 to 4 remote researchers. We projected live chat sessions on a large screen and the learners and teachers formulated questions and directed them at one or more of the experts (see figure 2). For efficiency, these messages were typed and sent as they were asked by one of the educational researchers.



Figure 2. Researcher types messages from the class to three remote scientists.

- *Accessing Remote Sensing Device Data:* When time permitted, learners used a web service (Benford et al, 2003) to access data (temperature, ice thickness, etc...) recorded by the Antarctic remote sensing device. First, learners predicted the shape graphs of data from the device would have (e.g. change in ice thickness over the year or variation in UV intensity over a day and at different depths). Then they downloaded the data required to test their predictions and plotted this using Excel. Teachers and learners then discussed differences in their predictions and actual data graphs.

2nd Period – Urban CO Monitoring

- *Mobile Data Collection:* Small groups of learners (2-4) used handheld mobile sensing devices (CO sensor / GPS / PDA – see left of figure 3), video cameras and anemometers to investigate CO levels around the University Campus formulating and testing hypothesis about CO dispersion as they did so. One or more adult participants (teacher and/or researcher) accompanied each group.
- *Data Visualisation and Sharing:* We then transferred GPS and CO data from the handheld sensors to PCs and learners uploaded this to a web-based online visualisation service. This returned a navigable VRML representation of where they had walked and the CO readings. Buildings in the local environment were represented as 3D blocks overlaid on a photographic map of the area. The route walked was drawn as a black line with variations in CO levels shown in shades of red (see right of Figure 3). Learners explored the visualisation of their data and compared this to their own experience and observations. Some also had time to compare this representation with simple line plots of the data showing CO levels over time, which they produced in Excel. In 3 of the 5 sessions, learners also had the opportunity to text chat with the researcher responsible for development of the CO monitoring device.

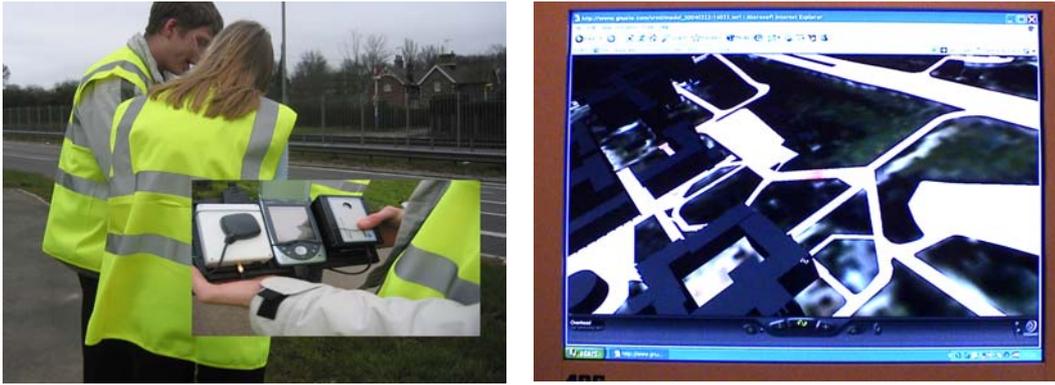


Figure 3. Learners gathering CO data in the field and reviewing data in the lab

- *Reflection:* Finally, learners were given a questionnaire asking them to reflect on this experience, define e-Science and suggest how similar technology might be used to support school science learning.

SENSE e-Science Sessions

The second series of e-Science sessions were conducted in-school and spanned a 7-week period during which learners worked in small groups on a CO air pollution project. Learners were recruited through a local secondary school in Brighton and were members of a Year 9 (aged 14-15) science class. A total of 19 learners, working in groups of 3-4, participated in the sessions. The SENSE sessions only referred to the *Urban CO monitoring project* and used the same handheld CO sensing devices as used for the Public Understanding sessions. A group of 8 of these 19 learners spent 1 session engaged in live communication with a remote classroom of Year 6 (aged 10-11) children who they were previously unaware had been engaged in a similar data monitoring project using similar equipment to theirs. This same group of 8 children on a separate occasion also engaged in a telephone conversation with a remote air pollution science expert. During this session the scientist described his work followed by a question and answer session where each student was able to ask their own question and report the answer back to the group.

SENSE e-Science Session Objectives

The aim of the SENSE project sessions was to use the exploration of air pollution and CO to develop full-lifecycle scientific enquiry skills among learners aged 13-14 years. These skills include: initial research into a scientific domain; planning an experimental study; articulating initial hypotheses; hypotheses testing through data-logging; reviewing results and communicating findings to others. The CO data-gathering activities engaged in followed a similar format to the Public Understanding project, but differed in the framing of the sessions (a scientific project conducted over a series of sessions) and timeframe (a 7 week period). The same video recording, CO and wind sensing and map logging equipment were used (Figure 4).



Figure 4. Learners gathering wind and video record data in the field

SENSE Session Structure and Activities

Learners were presented with a scenario where they had been asked to design and conduct a study to help the local Council decide whether road traffic should be banned from the school's surrounding area due to high levels of air pollution. This scenario was designed, with assistance from the school science teacher, to be consistent with air pollution as covered in the national curriculum. The sessions comprised of the following activities that combined familiar class-based work with hands-on data collection outside school, data reviewing and communication with remote others (Table 2). Sessions were scheduled around normal science lesson timetabling, hence were not always placed in consecutive weeks.

Table 2. Organisation of activities within the SENSE sessions.

Session number	Week conducted	Purpose	Activities conducted
1	1	Contextualisation	Introductory web-based research on air pollution and CO. Designing a small-group study for hands-on data-collection through route planning 3 or 4 locations to visit, and hypothesising about potential readings at each location.
2	2	Mobile data collection	Small groups of 3-4 learners used the CO sensor with GPS and PDA tools (Figure 3 left-side); along with a video recorder and wind monitoring equipment in the school locality (Figure 4). Each group was accompanied by an adult facilitator who prompted for hypothesis generation and testing.
3, 4	2, 3	Data visualisation and sharing	Students reviewed data back in the classroom using a prototype CO graphing and video synchronisation tool built for the project (Figure 5). Learners were able to annotate these graphs and view each other's group data.
5	4	Mobile data collection (part 2)	Planning and conducting a second data-gathering session to develop small-group hypotheses.
6	4	Data visualisation and sharing (part 2)	A similar data annotation and review session as sessions 3 and 4.
7, 8	5, 7	Communicating with remote others	Students engaged in remote communication with a CO scientist about their study and about his work via telephone. Review of similarly collected remote CO data by a Nottingham classroom that had followed a series of similar sessions using the data-presentation tool (Figure 5), followed by a question and answer session about the different ways each class had conducted their data-gathering.



Figure 5. SENSE user interface for reviewing, annotating and sharing data

Discussion and conclusions

Through feedback obtained from our student and teacher participants and reflecting on the studies conducted as part of the Public Understanding and SENSE projects, we found that both the learners and teachers were very enthusiastic about the experiences. Learners provided suitable definitions of e-Science and insights into how technology can be used in scientific research and their own learning and rated the sessions positively. Teachers felt the learners had been suitably challenged and successfully engaged in scientific enquiry. Indeed our analysis of interactions from these sessions supports these opinions revealing many episodes of enthusiasm, collaboration, hypothesis formation, testing, presentation of ideas, and reflection (Smith et al., 2005). However, teachers were particularly concerned about the amount of work that would be required of them in order to setup similar sessions. They also suggested that technology infrastructure and (often insufficient) ICT support and organisational issues would make similar sessions difficult to run within most schools.

Opinions like these are supported by our experience of running sessions within schools on the SENSE project, and on subsequent projects e.g. Homework (Luckin et al., 2006) and BBC Augmented Reality Trial (Smith et al., under review). Future work in this area will investigate thoroughly these and other challenges of incorporating e-Science fully into curriculum teaching, taking into account available teaching preparation time, school science budgets, levels of ICT support and the cost of maintaining working relationships with external partners through the “Towards making Grid-enabled schools e-Science usable and re-usable for and with teachers” project⁸. VESEL⁹ is a new project that commenced in September 2006 as part of the EPSRC ideas factory Bridging the Global Digital Divide initiative. The overarching aim of this project is to enable rural communities in Sub-Saharan Africa to use advanced digital technology to improve their agricultural practices and literacy levels. Partnerships between educational e-Science projects in the UK and creative uses of technology in different contexts and cultures e.g. finding solutions to sustainable methods for

⁸ <http://www.informatics.sussex.ac.uk/interact/escience-usability.htm>

⁹ <http://www.lkl.ac.uk/graphics/projectsheets/vesel.pdf>

generating electricity for hand-held devices, can widen science problem solving skills beyond examples applicable locally, to real and productive applications of e-Science.

We believe that active involvement partnerships between the public and research scientists will increasingly become a mandatory requirement of research grant awards from public funds. We are currently analysing the data collected from both projects reported here to comprehensively identify and specify the technology and resources required to efficiently enable and drive forward these mutually beneficial partnerships through schools e-Science.

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