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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 NeSC[1]

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:

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 theme[2] 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 Understanding[3] and SENSE[4] 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.

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

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[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

We ran five, three-hour Public Understanding e-Science sessions, with activities taking place both in a laboratory and around the campus at

- *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 th

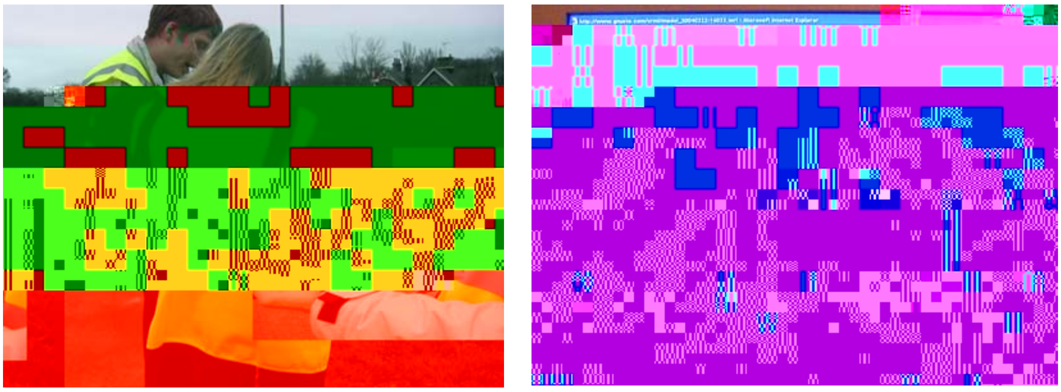

Figure 3. Learners gathering CO data in the field and reviewing data in the lab

- *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.

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

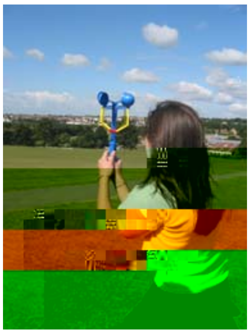 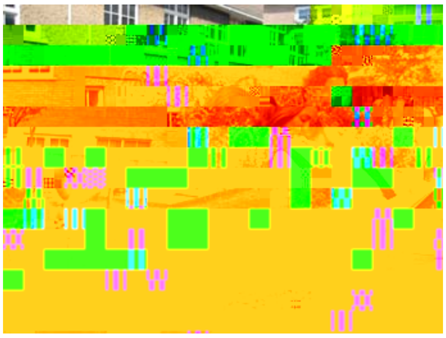

Figure 4. Learners gathering wind and video record data in the field

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

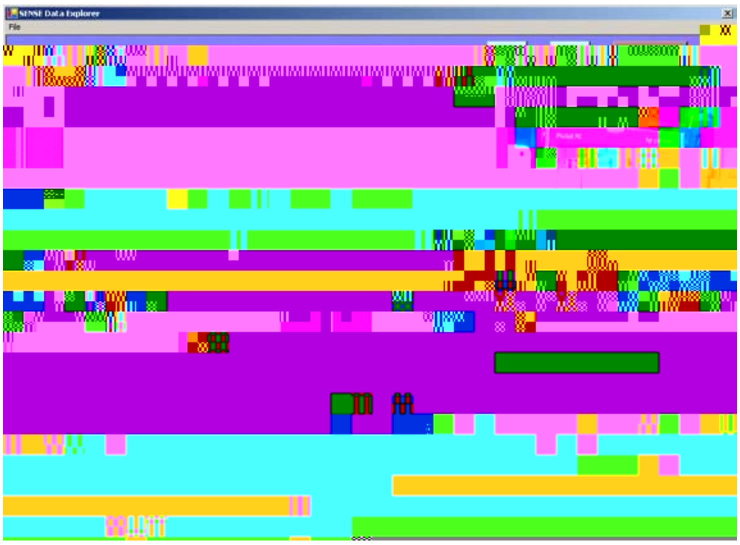

Figure 5. SENSE user interface for reviewing, annotating and sharing data

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" project[8]. VESEL[9] 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

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[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 requirem

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