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# Bringing School Science to Life: Personalization, Contextualization and Reflection of Self-Collected Data

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## Abstract

*We investigate the use of mobile and sensor technologies for school science investigations, to bring about a more engaging and hands-on approach to science learning. We report early findings from two trials carried out within the Participate project, where schoolchildren were given a range of off the shelf and newly developed technologies to carry out data collection and analysis tasks. Indications are that, not only are the tasks engaging for the pupils, but aspects such as personalization of data, contextual information, and reflection upon both the data and its collection, are important factors in obtaining and retaining their interest.*

## 1. Introduction

Social constructivist approaches to learning emphasize both hands-on experience, and social interactions with peers and others. This implies an acculturation or apprenticeship model of education, where learners construct meaning based on their experiences, within a given social and physical context. Our field of interest is science education, and previous work has shown that providing elements of an authentic experience of the scientific process can increase pupils' interest in, and engagement with school science [1]. By 'authentic scientific experience' we refer to activities that professional scientists carry out on a day to day basis. These tend to be social in nature (since most scientists work in teams), and include collecting and analysing data, relating new results to earlier ones, and communicating their findings. As these activities do not greatly differ from the things that we do as we go about our everyday lives, it is easy to start to move beyond the idea of science as difficult, and remote from everyday experience.

We build upon previous work such as *Ambient Wood* [2], where children engaged in a technologically-augmented field study. They were encouraged to explore and reflect upon the physical environment, identifying plant and animal species, and using sensors to measure abiotic factors such as light and moisture levels. Related information was sent to them via handheld PDAs, and they were given opportunities to reflect upon and discuss their experiences amongst themselves, and with adult facilitators.

Other work has gone a step further, allowing pupils and teachers to compare and discuss their results with others, not only co-present within their own classrooms, but also remotely across schools, and even, potentially, with professional scientists. For example, Roy Pea and his colleagues [3,4,5] provided internet-based environmental science activities which included adapted versions of the analytical and visualization tools used by professional scientists. Their aim was to replace traditional classrooms with 'virtual learning environments', distributed communities of scientists, teachers and students, whose interactions are facilitated by the internet and other digital technologies.

Technical advances, alongside the emergence of eScience as an aid to large scale collaborative endeavours in 'big science' fields such as biotechnology and physics, have sparked new interest in the potential of eScience for educational purposes [6]. Projects such as *Sense* [7] explored children's use of sensors to monitor the environmental impact of road traffic, and on

a much larger scale, the BBC's Springwatch [8] combined broadcast and internet resources to allow members of the public to contribute data to produce a national picture of the changing seasons.

In this paper, we draw upon the idea of providing authentic scientific experiences, and our own experience of the practical issues of working in schools [9], in describing two sets of pilot trials carried out within the Participate project. School pupils were given a range of mobile, and sensor technologies to engage in data collection and analysis tasks.

## 2. The Participate Project

Participate is a large scale collaborative project which aims to use pervasive technologies to inform environmental debate, among groups such as school pupils, computer gamers and community groups. Participants are encouraged to contribute their own material, in the form of text, images and video, as opposed to being mere consumers of professionally produced content. Project partners are the Universities of Bath and Nottingham, the BBC, British Telecom, Microsoft, Science Scope (a datalogger manufacturer), and Blast Theory (an arts company).

## 3. The Schools Trials

Pilot trials took place during 2006 and 2007. School pupils were provided with tools to collect, analyse, display, discuss and share environmental data. During the first trial, which involved two schools only, all classroom sessions were video recorded. In the second trial, involving up to 13 schools at various levels of engagement, only a sample of the sessions were videoed. However, expansion of activities meant that we could also collect other forms of data, to which we refer further on.

Work is currently in progress towards an integrated trial which will merge work carried out under the schools, gaming and community themes into a national campaign.

### Trial 1

This study took place early on in the Participate project. Activities were centred around the daily journeys that children make between home and school. Classes of 13-15 year old pupils in two schools were loaned a laptop

PC with Google Earth$^{TM}$ and Science Scope's graphing software installed, and five sets of data collection equipment. These comprised a Science Scope Logbook datalogger with a selection of sensors from which the pupils could choose, and a Nokia 66 series mobile phone with sound sensor software developed within the project, connected via Bluetooth to a GPS unit, the idea being that all the Latitude, Longitude and sound data would be saved in the phone's memory to a time-stamped KML file, which could be displayed as trails on high resolution 3D maps in Google Earth$^{TM}$. Sensor data from the Logbooks were to be displayed separately as conventional line graphs. Disposable cameras and notebooks were also provided. Once pupils had collected and downloaded their data, they then had one or more teacher-led sessions to work with the data.

### Data Collection

Pupils took turns to take a set of data collection equipment on their journeys home, collecting data as they went, on parameters such as carbon monoxide (CO), sound and temperature. The idea was to produce a snapshot of the conditions that they experienced on a daily basis, to promote discussion about how their personal journeys, whether by car, bus, bike or on foot, impacted on the environment and quality of life locally, and how the environmental conditions that they encountered on their journeys may in turn affect them. Data were then downloaded to the laptop PC.

### Working with the Data

The pupils were briefed that the trial would include new technologies that had not previously been tested in schools, and that consequently, they might experience technical problems. This uncertainty fitted well within our remit of scientific authenticity, and the pupils coped well with it. The only notable problem however was an intermittent loss of connectivity between the phones and the GPS, due to a software problem. Despite this, pupils succeeded in collecting short sequences of simultaneous sound and GPS data with the phones. These data were then manipulated by the project team to visualize them as data trails in Google Earth$^{TM}$. Data from the Logbooks were downloaded to Science Scope's graphing software (Datadisc Pt), displaying as coloured line graphs.

The pupils were very engaged by the Google Earth[TM] visualizations. The trails provoked considerable discussion about the routes taken, and possible causes of the data peaks. An example of a data trail produced in this trial is shown in Figure 1.
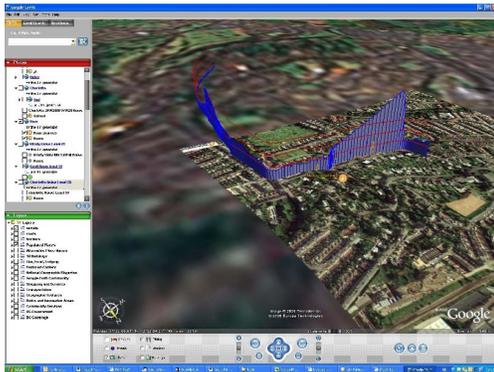


**Figure 1. A data trail in Google Earth[TM] from the pilot trial.**

Perhaps more surprisingly, an almost equally high level of interest was elicited by the other, quite bland seeming material that the pupils had collected. This comprised printouts of time and date stamped line graphs, some rather poor quality photographs and a few handwritten notes. Although these data lacked the impact of the Google Earth[TM] visualizations, pupils nevertheless spent long periods of time examining them, attempting to make sense of their results. Video analysis shows that one group of girls spent around 45 minutes discussing this material. First, they established who had collected the individual datasets represented by the graphs, and related them, where possible, to the photographs. They did this by memory; each remembering aloud when she had taken the equipment on her journey, and recognising landmarks or events shown in the photographs. This process involved considerable discussion, prompting of one another, and reconstruction of events. Once they had established ownership of the data sets, they then moved on to discuss what might have been happening at various points on the graphs, using the photos, where available, to hypothesize about causation. Although the data seemed unexciting, and interpretation required considerable effort, they were motivated to do so because the material was personal to them, and reflected their own activities.

## 3.4 Opportunities for Further Reflection

To conclude the trial, BBC colleagues ran a '60 second scientist' film-making workshop at each school. Groups of pupils were helped to make short films centred around the trial activities. Each group was given a topic or question upon which to base their ideas, and shown how to storyboard, shoot and edit their own short film. The day finished with a general viewing of all the films. This activity was intensive and engaging, encouraging pupils to reflect upon both their own activities, and environmental issues more generally. They spent a lot of time discussing their experiences, and looking for additional information on their topic. We included an adapted version of '60 second scientist' in the second trial. Further investigation of the use of film as a tool to consolidate learning and promote reflection, or even as an assessment tool, to gauge learning, would be worthwhile.

## 3.5 Trial 2

Trial 2 was larger in scale, involving 13 schools at various levels of engagement. Linked activities have also taken place at out of school events for young people, such as the World Scout Jamboree, held this year in the South of the UK. As in the earlier trial, dataloggers, sensors and GPS were used, though some changes have been made to the technology based upon revised research requirements, feedback from participants, and the need to render the activities more appropriate for the involvement of multiple schools. For example, this time we did not use mobile phones, both because of the difficulty in providing the number of phones that would be required for an extended trial, and also due to the need of members of the technical team responsible for phone software to concentrate efforts in other areas of work. We retained the compelling Google Earth[TM] visualizations, or Google Maps if preferred. This time, data from the loggers and GPS were downloaded to a program called JData3D, produced by members of the project team. This program automatically displays the time and location stamped data as trails in Google Earth. Additionally, pupils' digital photographs can be incorporated with the data, and opened by clicking on placefinders along the data trails.

To support storage and sharing of data, a secure website has been developed

(www.participateschools.co.uk). Teachers can control the setting up of pupil groups, access to different areas of the site, and the upload of both data trails, and class work in the form of digital posters and short films. Instructions for creating these are on the website. The site thus enables the controlled sharing of data and other materials between participating schools, while still maintaining the security and privacy of children's personal data. Observations indicate that the combination of data visualizations and pupil generated material is compelling as a learning and sharing tool, engaging pupils and encouraging discussion.

Alongside video analysis, we devised pre- and post-test pupil questionnaires for this trial, to gauge changes in subject knowledge and attitudes to collaboration over the course of the trial, and in the case of the post-test questionnaire only, elicit feedback on usability. Additionally, teachers were interviewed during and after the trial activities. Only limited analyses of these materials have so far been carried out.

## 4   Findings

The SENSE project [7] showed the importance of providing information on the context of scientific data collection, to facilitate pupils' understanding of the data's significance. Contextual information was provided via video footage of the data collection process. When video was displayed alongside graphed CO data, children discussed and reflected upon both the activities and the findings. In Participate too, we are finding that contextual information is an important factor in facilitating understanding. Context in this instance is provided by means of data trails in Google Earth$^{TM}$, clearly showing routes taken, and the levels of the parameters measured along the path followed. Additional contextual information can be provided by means of linked photographs.

Apart from the issue of context, indications are that personalization of the data, and providing interesting activities to help pupils to reflect upon what they have done, were also of significance. Pupils were keen to take ownership of the data, and this appeared equally true of bland data forms such as line graphs, as of richer material such as Google Earth$^{TM}$ or Google Maps visualizations and photographs, When pupils collect their own data, they are motivated to make much greater effort to grasp its meaning than they would in the case, for example, of

similar material shown in a textbook. The importance of reflection in learning is well known, and is a key factor in professional training in various disciplines [10]. Our observations indicate that opportunities for reflection can be provided by various means, such as discussion, working with and interpreting self-collected data, and creating and sharing material such as posters and films based upon the activities.

## 5.   Discussion and Further Work

Early findings have raised a number of questions, and we are currently devising further studies to address these. For example, in relation to contextual information, some studies carried out within the second trial suggest that providing more than an optimum amount of contextual information, can, rather than promoting discussion, have the effect of reducing the time spent on discussing the results. In one example, Google Earth$^{TM}$ visualizations with associated photographs downloaded automatically on a large screen, though engaging, (indeed passers-by frequently crowded round to look), did not elicit as much discussion as either the line graphs produced in the first trial, or instances where Google Earth$^{TM}$ visualizations were displayed without the addition of photographs. Where reflection and discussion activities are reduced or absent, it may be less likely that the learning is retained.

We are aware that data distribution over large networks can remove the rich contextual factors of real-world settings afforded by local experience. We therefore need to discover whether the type of contextual information required by those who have participated in the collection of data, and those who are viewing others' data when they have not been co-present during its collection, is the same or different, in the light of the need to reach the equilibrium of enough context data to personalise the experience, while not making it so seamless that discussion is no longer needed. We also need to investigate more closely which types of post-data-collection activities are most effective in terms of reflection. This may vary according to the ages and abilities of the pupils in question.

Pupils and teachers have told us that, when carrying out scientific experiments, a single one off study is not sufficient, ie that it is not 'good science' to draw valid conclusions from an experiment that has only been carried out once, without the opportunity for repetition. It is also

the case that, the first time you engage in a data collection activity without the availability of baseline data, it is difficult to understand the range or meaning of the readings. For example, one group of pupils asked what was a 'normal' light level when examining light data. Only on measuring light levels over time, and at different times of day, was some understanding gained about the meaning of the data. All of this implies appropriating the technology to remain in the schools over long periods of time, rather than on a short-term loan basis, and familiarisation of use by teachers as well as the research team. One possibility is the siting of fixed sensors in the local area from which children could repeatedly collect data, so that they have particular points of investigation. Another is presenting investigations in the form of specific campaigns or missions in which multiple schools can take part. The project team are currently considering how such opportunities can be provided in the national trial.

## 6.     Conclusion

Our analyses are still at an early stage. However, indications are that these strategies are effective in engaging pupils' interest in science, by providing them with elements of an authentic experience of what scientists do. Factors such as the relatively inflexible nature of the curriculum, which only allows limited time for individual topics, can prove problematic. However, if we wish to engage children in science, whether our intention in doing so is to produce future scientists, or more prosaically, to ensure that the next generation will be equipped to participate in informed debate on scientific topics, we feel that work of this kind has the potential to do so.

## 7.     Acknowledgements

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