Designing new learning experiences with pervasive technologies

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http://www.lkl.ac.uk/research/index.html
London Knowledge Lab

http://www.equator.ac.uk/
Equator

The world is witnessing a phenomenal rise in the development and availability of mobile pervasive technologies, such as wireless handheld computing devices and smart phones. This trend is set to have a huge impact on the way children learn, turning existing views about how computers are used in classrooms on their head. Imagine you are learning about why certain organisms and plants grow or live in particular environments. You can see how big the plant is, where it is growing, what kind of leaves it has, but you can't see all of the processes involved to keep the plant alive, nor can you see what it will look like at different times of the year. This is where the new technologies can really offer something different. Imagine being able to 'see' the plant breathing and feeding. Imagine that you can also take measurements of the light shining on the leaves, the nutrients in the soil and the moisture surrounding the plant. Imagine collecting this information for several different plants and comparing your results with where and when they grow, and in relation to one another and other organisms in the environment. Suppose you could then review the information you have seen and collected back in the classroom. Technologies such as wireless computing, digital probes, sensor technologies, and handheld devices like PDAs can help to make all this possible.

Advances in mobile and pervasive computing are providing opportunities for thinking quite differently about how to support, encourage and motivate children in their learning. The embedding of computers in everyday objects and the surrounding environment means that innovative learning environments can be designed both indoors and outdoors. A diversity of learning activities and interactions can now be enhanced in ways not possible before. For example, information can be presented or played via wireless speakers and embedded displays (in objects or the environment) or mobile devices (carried or worn by a child) at opportune times that are pertinent to the task at hand. Such interventions and augmentations can guide, stimulate and incite children into reflecting and remarking upon them in relation to what they are currently engaged in – encouraging new forms of collaborative and self-initiated learning that is 'active'. This, in turn, can lead to deeper and more integrated understanding, even enabling the discovery of what is "going on in their own heads" (to speak in the words of Bruner).

In our research, we have been investigating how to design and combine new technologies to encourage new forms of active learning. Our goal is to extend and support children in building their own understanding, based on what they already know, together with a world of 'augmented' digital information that is experienced through a congeries of devices and displays situated both in the classroom and other outdoor settings. Examples of augmented digital information include previously stored data, images, photos, sounds and simulations. A particular emphasis is on enabling children to make personal connections between the augmented information they gather, glean, collect and connect in the physical spaces with the abstracted knowledge that is imparted to them in the classroom.

One of our first forays into designing pervasive technologies to support active learning was the Ambient Wood project that ran in 2003. Various wireless and sensor technologies, devices and representational media were combined, designed and choreographed to appear and be used in a physical woodland. The idea was to enable children (aged 10-12 years) to integrate, build and reflect upon their classroom learning for the topic of habitat distributions and interdependencies through their explorations of an 'ambient' wood; whereby various digital augmentations collected and experienced in the context of the physical woodland would provide them with the means of achieving this.

Several handcrafted listening, recording and viewing devices were created to present the digital augmentations, making the invisible visible and the inaudible audible, while also bringing the far to the near, and seeing the past and the future in the present. The digital augmentations comprised sounds of biological processes, images of organisms and video clips of life cycles: some were triggered by the children's exploratory movements, others were collected by the children, while still others were aggregated and represented as composite information visualisations of their exploratory behaviour. A wireless infrastructure also monitored the children's positions in the woodland, tracking the location and data the children collected, and triggering location-based information. Examples of the tools included: a *PDA display* that popped up images of a plant or animal together with a voice-over describing an aspect of its habitat, whenever the children passed by a motion sensor strategically placed in different parts of the wood (eg, next to a thistle); a *probe tool* that enabled the children to take real-time measurements of moisture and light anywhere in the woodland; and an *ambient horn* that played various ambient sounds that were again triggered whenever the children walked past location-based sensors embedded in the environment. The children were also given walkie-talkies to communicate their findings and observations and to answer questions sometimes asked by a remote facilitator. The remote facilitator also sent images back to them that then appeared on their PDAs of what he/she thought they were describing.

http://www.cogs.susx.ac.uk/projects/equator/workshops/horn/hornindex.htm
The ambient horn

Pairs of children explored different parts of the physical woodland and used the various tools and devices. They probed many aspects of the woodland (including themselves!), taking it in turns to either probe or read the outcome on the PDA. They also used the tools to initiate scientific inquiry. For example, one pair used the probe tool to generate hypotheses about why certain parts were drier (eg, leaves) than others (eg, grass) and what this meant in relation to what would survive there. Thus, the children were able to link the information appearing on their devices with what they had previously learnt, together with what they were seeing and hearing in the environment, enabling them to develop a deeper understanding of the various habitat relationships and distributions.

To build up their learning further, the children were later given the opportunity to revisit the data they had collected and observed by viewing it on a large bird's eye digital visualisation of the woodland. This was presented via a large screen display placed in a tent in the middle of the wood. In particular, their recorded light and moisture readings were displayed as visualisations on a map, enabling the children to see collective distributions of their probe readings. All the children were fascinated that every probe reading they and the other children had collected had been recorded and was now available to them as interactive data points on the visualisation display. By clicking on the data points the children could bring up the same readings they had seen on their PDAs whilst in the woodland. This combined ground level/bird's eye level mapping proved to be a very powerful representation for encouraging reflection: by seeing each other's data from the two different perspectives, the children developed an overall picture in relation to their own personal experiences and were able to make generalisations about the contrasting habitats. It was also found to be highly amusing, especially when the children tried to find the data points of where they had probed parts of their bodies.

The digital data and information collected, heard and viewed in the woodland was again re-represented in a classroom setting to support further reflections about the interdependencies in the woodland habitats. This time the information was back projected onto a shared horizontal surface. The children used their digital data to begin to build representations of ecosystems using physical tokens of the organisms found in particular locations in the wood. This helped them think about the habitat distributions and interdependencies experienced in the woodland at a more conceptual level, supporting a full circle of abstract to concrete to abstract understanding via the interlinking of physical and digital spaces.

More recently, we have been investigating how active and integrated indoors and outdoors learning can be designed for other types of science-based settings. For example, the Lilly Arbor project currently being conducted in the US is concerned with how students can learn about environmental restoration and reforestation, by working with environmental scientists using a variety of sensor-based, handheld technologies when in the field. These enable them to record measurements, access historical and graphical data about specific aspects of the environment, eg, water quality and tree growth, and to revisit these by inspecting the accumulating datasets presented as large interactive visualisations in the lab and in the classroom. Similarly, as part of the Equator eScience project, students were able to investigate how remote and portable sensors were being used by scientists to measure carbon dioxide levels in both the Antarctic and an urban setting, while also participating in a study of the relationship between the carbon cycle in a specific Antarctic lake and pollution in a city. A follow-up schools project, funded by JISC, explored the potential of mobile and wireless devices, including mobile sensing devices for supporting students' scientific enquiry skills while learning more about pollution. Software visualisations were developed to enable pupils to upload collected data and to integrate and re-represent different data sets to support discussion and communication in the classroom. These were also integrated with GRID technologies to support students comparing data collected from their own environment with data from other more distant environments.

The Lilly Arbor project
ttp://www.cees.iupui.edu/Research/Restoration/ARBOR/index.htm

The eScience project
http://www.cogs.susx.ac.uk/interact/projects/escience.htm

eScience schools project (SENSE)
http://www.cogs.susx.ac.uk/interact/projects/escience-pollution.htm

These projects show how pervasive computing can be used to design active learning experiences that can broaden and connect children's and students' understandings, reflections and hypotheses across both real world and classroom settings for science topics. We also propose that the new technologies can be used to aid a deeper understanding and appreciation of a range of other subjects, including mathematics, physics, chronology, homeland security and even politics, by designing novel learning experiences through the use of one or more of the following:

- Mobile devices connected to wireless networks that enable children to access, compare and record information while in the field.

- Information and collected data being sent to others, in different physical or virtual environments, enabling novel forms of collaborative problem solving to occur in real time over distance.

- Contextually-relevant digital information (eg, images, sounds, visualisations, questions) being delivered through location and person sensing, via handheld devices at relevant times and situations, to focus particular kinds of learning activity in the field.

- Novel viewing and tangible computational devices, designed to enable information and live data to be presented, collated and interacted with collaboratively.

- Interactive tabletops and large public displays to show 'personal' data collected by learners over time and space, enabling them to identify and track their own data relative to that of others.

http://www.sussex.ac.uk/Users/sarap/
Sara Price's site

http://www.cogs.susx.ac.uk/users/yvonner/
Yvonne Rogers' site

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