Learning with 'non-interactive' technology

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Abstract
The use of information and communication technologies in education has been, and continues to be, studied extensively. Much of this research, however, is confined to an increasingly antiquated conception of single learners sitting in front of single desktop computers, whether learning alone or collaboratively. As computers become increasingly mobile, invisible, and ubiquitous, we interact with many systems daily, and their use particularly in informal learning - for example in museums, in navigation, learning at home - is increasing. The technology continues to outpace theory. Our research attempts to close this divide by beginning to build a conceptual space for thinking about learning in a world where networked computers are embedded everywhere.

We describe a location tracking technology which enables what we call "non-interactive computing" - the ability to interact with a computer merely by moving around a space. Our intention here is to explore what it means for technology-enhanced learning when the technology is available but invisible. We seek to formulate theories and methodologies before technologies such as these arrive on a large scale - not to react to technological change but to influence it.

Introduction
Weiser (1991) sketched a vision of the 21st century in which computing technology is seamlessly woven in to the fabric of our lives. So-called "multimedia computers," he said, are anything but - forcing us to sit in front of a screen and interact with the computer on its terms. In contrast, his vision of "ubiquitous computing" was to bring computers into the human world.

A decade later, a group of researchers reported their vision of future "ambient intelligence" with a series of scenarios (ISTAG, 2001) - one of which concerned education. It portrays a group of people coming together - physically and virtually - to study environmental science, supported by a system embedded in the room which communicate using voice and projected visuals. It contains personalized information about each of them, and it both shapes and adapts to activities that occur throughout the session.

In the technology community, the terms "ambient" and "ubiquitous" have slightly different meanings, but to us this makes little difference, for we are concerned merely with the fact that where once we regarded a computer as part of a learning environment, we must now consider the environment itself as a computer, whether accessed via mobile or ambient means. Some of our previous work has focused on mobile learning (e.g. Walker, 2004), wearable technologies (e.g. Kanis et al, 2004), or technology in museums (Walker, 2001).

Scenario

A family goes to see a new exhibition of Egyptian artifacts. All receive badges which they carry throughout their visit. One of the children discussed a particular artifact with another child he meets. At the end, all receive a printed ticket with some login information or, if they prefer, an email or text message. There are some computers at the end, but the family opts to log in later. The new two new friends share their login information so they can link their trails.

At home, when each member of the family logs in, they find a personalized web site detailing their visit. Artifacts they have lingered over receive more detail, and discussions have been recorded. The child who made a new friend edits and annotates his trail, then sends it to his friend using the friend's login. This leads to further collaborations. Long after the exhibition closes, the friends continue to virtually "meet" there and eventually learn about every single artifact, as well as others they find out about together. Other museums offer themed trails through their collections, and a community of people share their own trails online.

Architecture

We are evaluating a location tracking technology which uses proximity-based location sensing over ad hoc (Bluetooth) wireless networks. It contains sensors to capture multimedia content, and can transmit and deliver digital content to and from centralized data storage. Thus a user can capture and transmit audio over the network in real time, to give commands or to communicate with someone else. Since the tag does none of the processing or recording, it can be small and inexpensive, such as a badge or tag. Since the system uses proximity instead of direct contact with a computer terminal, users are freed to interact wherever they want within range of the network.

The receivers are similarly small and unobtrusive, slightly larger than a mobile phone. They can be powered using AC, batteries, or solar panel. Together they form ad hoc networks, which are able to locate the proximity of the tags, each of which has a unique I.D.

At the server (a standard desktop computer which can be on-site or remote), artifacts or exhibits are classified as "learning objects", and can each be associated with a single web page. Together with any data recorded to the server, a trail record can be constructed, along with any evidence of collaboration - voice recordings of participants, proximity information between tags, the same learning objects visited. This information can be delivered at the museum or remotely, for example by printing login information onto personalized tickets (see Walker, 2003).

Discussion

Technologies usually regarded in terms of surveillance can instead be used for human- and environmental-scale learning interactions. What we have described enables a type of "non-interactive computing" - the ability to interact with a computer merely by moving around a space; all input and output devices are more or less hidden.

New technologies of this type do not make existing theories obsolete. On the contrary, some cognitive and collaborative approaches become increasingly important, though their focus shifts from human-computer interactions to human-human and human-environment interactions. Cognitive load theory (Sweller et al, 1998), for example, remains relevant. In museums, for example, the split-attention effect is especially common. The addition of technology is such spaces - often in the form of focused, screen-based presentations, including handheld devices - can exacerbate this. Similarly, Mayer's (2001) cognitive theory of multimedia learning contains important considerations for optimizing the design of an information space.

Many social learning theories, including activity theory, focus on goals and the mediation of tools. This focus may not be appropriate for informal and unstructured learning scenarios such as museum-based or mobile learning. Theories such as distributed intelligence (Pea, 1993) may be more relevant in such scenarios, viewing knowledge as embodied socially and in the designed environment as well as in artefacts.

In a computing environment without standard interaction devices such as keyboard and mouse, the notion affordances become very important. Their definition and use in on-screen environments has been debated in the HCI community. But in a physical environment their meaning returns somewhat to Gibson's (1979) original definition, which regarded them as perceived actionable objects in the natural world.

Since technology pervades so much of our environment, an even broader model can be useful. Van de Velde (2003) has conceptualized the world itself as a type of computer, and he suggests broadening our notion of architecture to include information (see also Walker, 2001). This draws on the work of Alexander (1977), whose "pattern language" centers on "occupational narratives."

Viewed from a social learning perspective, the technology we have described could be used not only to monitor activity, but also provide feedback to learners, including not only learning content, but contextual information from the environment or external sources, as well as suggestions based on these. So the trail, context, and external information are not used only after the learning experience ends, but can influence it with a real-time feedback loop.

This is meant merely to lay a theoretical foundation for future work - much remains to be done particularly with regard to the trail representation and granularity.

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