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In this chapter we describe how mobile technologies are transforming learning. We start by taking stock of the burgeoning area of mobile learning research and describe both the benefits and challenges of using mobile technologies to support children’s learning. We explain what is meant by mobile learning and provide a review of four core developments in the area: physical exercise games, participatory simulations, field trips, and content creation.

**INTRODUCTION**

Children have always loved running around, whether chasing one another through a shopping mall, darting along a beach, or playing hide and seek in the woods. Nowadays, with a selection of mobile technologies stuffed in their pockets or around their necks, they can do more than simply enjoy the moment. With a digital camera or an iPod at the ready, they can take pictures or record sounds they encounter during their outdoor pursuits. They can tag these artistic creations with comments and other personal details and then upload them to Facebook or another social Website to share them with their friends, teachers, or family.

Specialized handheld tools such as digital probes are also changing the way children explore and relate to their “neck of the woods.” For example, they can measure the level of carbon monoxide being emitted from their school bus as it chugs its way past their homes, schools, and playing fields. They can update their data and compare it with similar types of data collected by children in other parts of the world, creating an online global map that shows school bus pollution hotspots.
Another creative development is a digital necklace that children can wear as part of a simulation game in which they each pretend to be a virus. As the children move around a physical space, they try to avoid or come into contact with each other, mimicking the way viruses spread a common cold. The sensors on their necklaces do the spreading, the outcome of which is depicted on a computer display. The contacts made by the viruses appear as a brightly colored pattern that children can analyze and through which they can trace their own spreading trajectories.

These are just a few examples of ways in which the new generation of mobile technologies is changing the way children learn. Not only is mobile learning highly engaging, it also provides children with novel ways of relating their physical experiences to abstract knowledge, from running around a playground to understanding what a carbon footprint is. These innovative forms of physical digital switching are thought to lead to a more in-depth understanding of a topic. They also increase children’s opportunities to make connections between their observations and ideas that can help them grasp difficult concepts.

But how do mobile learning applications compare with PC-based, educational software programs that are now commonly used in schools to teach subjects such as math, language arts, or science? An important difference is the way fixed and mobile computers are used. PCs are deskbound and ideally suited to individual or pairs of children sitting in front of a computer screen, focusing their attention on solving a problem or completing a set task during a lesson. Mobile technologies are handheld and ideally suited for relatively short bursts of use (such as entering and comparing data or looking up and reviewing information) while involved in foregrounded physical activities, such as exploring a forest. In other words, PCs support sedentary children working primarily on digital tasks in the classroom or home, whereas mobile technologies support embodied children engaged in a diversity of physical activities and contexts.

An advantage of learning while mobile is that children often become more motivated and engaged than when staring at a PC while sitting still. But more significantly, mobile learning opens up many new opportunities for ways in which children can learn. What appear to be disparate activities can now be integrated over time and space. By making more connections between their emergent ideas, prior knowledge, and ongoing observations of the world, children are starting to view and understand the world differently. This development in educational technology represents a major shift in the way computers can be used to stretch children’s minds.

**MOBILE LEARNING**

Several researchers have suggested that we are entering a new era of technology-enhanced learning, characterized as mobile learning (e.g., Sharples et al., 2005; Tatar et al., 2003), seamless learning (Chan et al., 2006), and ubiquitous learning (Rogers et al., 2005). Central to these notions is the idea that mobile technolo-
gies can be designed to enable children to move in and out of overlapping physical, digital, and communicative spaces. This mobility can be achieved individually, in pairs, in small groups, or as a whole classroom together with teachers, mentors, experts, parents, professionals, and others (Chan et al., 2006). It is assumed that mobile technologies provide continuity across various learning experiences, enabling children to make connections between what they are observing, collecting, accessing, and thinking about over time, place, and people. For example, a child might use his iPhone to chat with a mentor in Second Life about biodiversity while sitting on a bus and then, based on the expert’s suggestions, join in a snail hunt in his local park, take photos with his phone, tag the snails’ location using GPS coordinates, and then send the data, with a suggestion as to what the snails are, to an online Website on biodiversity. The biologists monitoring the site could then send a message back to him verifying whether his identification of the snails was correct and could then add his data to a national database that the child could subsequently show to his biology teacher at school.

There is an ongoing debate about how this kind of mobile learning can encourage new forms of social interaction, thinking, or reflection (e.g., Pachler, 2007; Sharples et al., 2008). As shown in the previous example, being able to communicate with others what one is thinking and seeing is an integral part of learning. Through explaining to others and representing information via various media, children can be made aware of their own discrepancies in understanding, enabling them to revise their understanding (c.f. Chi, 1997). “One way in which learners may gain from working closely on a problem is by being required to make their thinking public and explicit” (Crook, 1994, p. 133). Collaboration can increase awareness, which in turn can enable children to reflect on what they are currently engaged in.

Another concern is whether the focus should be on the technology being mobile or the extent to which the learner is mobile (Traxler, 2005). In some contexts, it is important that the activities are highly physical; in others, the portability of the mobile technology is more critical. For still others, it is the way the device is used among a group of children during a task that is important. If children are each given a mobile device, this can promote working by themselves, whereas if they have to share one, they are required to collaborate more.

Several researchers have sought to explain the principles behind mobile learning (e.g., Sharples, 2005). Some have proposed existing learning theories, such as constructivism; others have suggested that new theories are needed. Most studies to date that investigate mobile learning have been based on or informed by constructivist theories of learning, drawing from Vygotsky (1978) and Papert (1980). These propose that we construct knowledge and meaning from our experiences and that this is best achieved through doing or making things. Another approach has been to cast the theoretical underpinning of mobile learning more broadly in terms of embodiment (e.g., Marshall and Rogers, 2009; Price et al., 2009). Embodiment refers to the interactions and conversations
that happen in our physical and social worlds and provide meaning (Dourish, 2001). A focus is on the intricate relationship between perception and action and the way that bodily experiences inform our understanding of abstract concepts. For example, abstract concepts, such as *above*, *below*, *up*, and *down* are understood through being physically experienced in the world (Lakoff and Johnson, 1980). Given that mobile learning typically involves acting and communicating in a physical and social world, rather than constructing things per se, it follows that ideas arising from embodiment may provide a more extensive account.

**MOBILE LEARNING ACTIVITIES**

A number of mobile applications and tools have been developed to augment learning. We describe these here in terms of four types:

- Physical exercise games
- Participatory simulations
- Field trips and visits
- Content creation

**Physical exercise games**

Mobile technologies have been incorporated into a number of physical activities to encourage children’s understanding of abstract phenomena. For example, *FloorMath* combines a sensor-embedded floor mat with a visual representation of the number system that appears on an adjacent screen (Scarlatos et al., 1999). When children walk up and down the squares, the corresponding numbers change on the screen. Walking the numbers is thought to make the activity more meaningful, helping children to see and understand abstract concepts in a new way (Scarlatos, 2006, p. 295). Similarly, *SmartStep*, developed by the same researchers, requires children to play hopscotch, skip, and count at the same time when practicing basic math skills (Figure 1.1). This combination of physical and mental activities is meant to hone motor skills, pattern recognition, rhythm, and coordination.

Physical exercise has also been coupled with other kinds of informal learning. Spikol and Milrad (2009), for example, developed a game called *Skattjakt* (*Treasure Hunt* in Swedish) that encourages teams of teenage children to simultaneously run around a physical environment, in this case a castle located on the university campus, to solve a mystery using mobile devices. The game design was inspired by orienteering, a traditional Scandinavian running sport involving navigation. Instead of mapping the physical exercise directly to the learning of abstract concepts, it is loosely coupled to orienteering skills, such as reading maps, and learning about history and team collaboration. Cell phones present text and audio-based clues at particular times, showing where the teams are on an interactive map of the whole area. Teenage girls playing the game readily understood the connection between the physical exercise demanded of them.
and the practice of orienting skills. For example, one girl commented: “There is a different feeling running when you have an added reason to do it.”

Nintendo Wii applications are also beginning to be used for learning various physical and cognitive skills. Kahol and Smith (2008) found that playing Marble Mania improved the dexterity skills that are needed for performing surgery; Vannoni and Straulino (2007) showed that children were able to learn about force, velocity, and acceleration through using a Wii remote to measure acceleration of a swinging pendulum.

All these applications use mobile technologies to bootstrap physical activities (e.g., walking, running) with learning math, physics, or other cognitive skills (e.g., orienteering). At the same time, if the physical exercise is designed to be strenuous, children’s health can equally benefit through the children having to run, walk, or cycle while learning.

**Participatory simulations**

A *participatory simulation* is a game in which sensor-based devices are worn or carried by children to enact a complex phenomenon, such as epidemiology. Each child plays the role of an element (e.g., a virus) at ground level that they then view at bird’s-eye level to see how their individual contribution affects the whole system (Colella, 2000). Participatory simulations have been developed to represent a number of systems and have been played out in various settings, including classrooms, museums, and playgrounds. They include (1) dynamic systems, such as a flu epidemic; (2) embedded naturally occurring phenomena, such as an earthquake; and (3) imaginary worlds, such as a magical place.