Tabletop Computing as Educational Technology

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Learning by Doing

An important challenge for modern educators is realizing Dewey's vision of *learning by doing* by creating learning environments that emphasize active learners and learning through inquiry (Bruner, 1966). In *inquiry-based learning*, learners discover new knowledge through experiments. By arriving at the knowledge themselves, stronger mental connections are forged and related inquiry skills are practiced. In *constructionism*, learners create personally-meaningful public artifacts with tools that allow them to engage important ideas (Papert, 1991). Because the artifacts are personally meaningful, it follows that learners are able to forge a more meaningful connection with the ideas. In both of these approaches, there is an emphasis on creating powerful tools that make important ideas accessible. This emphasis on environments and tools, rather than lesson plans, can be traced back to Montessori's prepared environment and Fröbel's manipulatives (Standing, 1957). The computer is a powerful tool for creating such environments (Rick & Lamberty, 2005).

One active area of research is designing computer environments to support collaborative learning, since effective forms of collaboration can enhance learning. Furthermore, students can learn together in small groups without constant attention from a teacher. Developing tools and software to support collocated collaboration has been, until now, constrained by the single user technology (e.g., PDAs, PCs) that was available. New shareable interfaces, however, offer great potential to open up new possibilities, enabling students to work together fluidly for a number of activities.

One relevant theory of collaborative learning is Roschelle's (Roschelle, 1996) theory of *convergent conceptual change*—when two learners work together with a *reflective tool* (a tool that responds to user input to reflect the embedded domain concepts), they tend to converge on an understanding that is better than either would achieve independently. When learners work together on a challenge, they naturally articulate how they would solve the challenge, based on their understanding. If their strategies clash, it triggers them to justify their understanding. The reflective tool allows the learners to demonstrate or test their understanding. Thus, an understanding can be confirmed or rejected. As they work on the challenge together, learners' conceptual understandings do not just converge with each other, but also with the domain concepts embodied in the tool.

Roschelle's model of collaboration is particularly compelling, because it shows how collaboration between equals can benefit both partners. On the flip side, if collaborators are not evenly skilled, as is often the case in a classroom setting, a more appropriate model of collaboration may be that of Vygotsky's (Vygotsky, 1978), where a more skilled person helps a less skilled person gain competence. No matter which model of collaboration (even or uneven) is appropriate to a specific pair, we would still expect the collaboration on an inquiry task to benefit learning.

Tabletop Computing

Single display groupware was developed ten years ago as a framework for software applications that support multiple users sharing the same display, typically using multiple mice or pens as input devices (Stewart, Bederson, & Druin, 1999). Single display groupware has been shown to better support collocated collaborative learning than taking turns on single-user application (Inkpen, Ho-Ching, Kuederle, Scott, & Shoemaker, 1999). One single display groupware that is rapidly maturing is *tabletop computing*—horizontal displays that can be directly engaged with finger touches or by moving tangible pieces.

Currently, the ShareIT project is developing software for MERL's DiamondTouch table (Dietz & Leigh, 2001) to support collaborative learning and studying its use with intended learners. Three applications have been developed. OurSpace allows students to position desks and students in a classroom; in our user studies, groups of three students collaborate on creating a seating layout for a (fictional) class that will occupy their classroom in the following year. DigiTile is a constructionist toolkit for designing colorful mosaic tiles (Rick & Rogers, 2008); two learners collaborate on design challenges to engage mathematical concepts of fractions and symmetry. WordCat requires two users to agree on categorizing words into a two-by-two matrix.

In developing these applications, we are often inspired by previous innovative educational technology. DigiTile is a port of DigiQuilt (Lamberty, 2007), a single-user desktop application. WordCat is a port of ClassiCat (Kerawalla, Pearce, Yuill, Luckin, & Harris, 2008), a mouse-based single display groupware. Our research goal is to realize and understand the potential of tabletop computing to support learning by doing. Adapting existing (successful) applications allows us to significantly shorten the development time and gives us a basis of comparison for our research.

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