# Sabbatical Mini-Report #5:
# Technology and Learning

Jack Rotman, Lansing Community College
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The issue is not "whether technology should be used in learning". In general, the questions deal with which technology, and how best to employ technology in learning. This report deals with the broad categories of calculators, online learning, and other technologies.

## CALCULATOR … especially the Graphing Calculator

**REPRESENTATIONS** (CALCULATOR … especially the Graphing Calculator)
One of the strengths of the graphing calculator is the ability to provide different representations – symbolic, graphic, and numeric. These representations are often used to supplement the other representation – verbal. A critical note in the research is the suspicion that the 4 modes of representation are not equal (see Gagatsis, pg 287). A research study tested the hypotheses that the modes were equally valid for developing learning; the data did not support this hypotheses … with the conclusion that some modes of representation were more important. The study did not look at "which representation" might be more important – it merely showed that learning can not be explained by a subset of the modes; some representations are a prerequisite to other(s).

The graphical representation of the calculator is often an emphasized mode, and we sometimes operate on the belief that many students are "visual learners". However, there is evidence that the visual components of memory are not processed as efficiently; in particular, working memory (short-term) tends to be phonetic while long-term memory tends to be semantic … visual information is secondary in both cases. See Goldstein pages 149 to 168.

The current model of working memory indicates that phonological (sounds) and visual information can be processed separately; see Goldstein pages 166-168 and Bruning page 122. Since phonological information may have a "priority" in the brain, the visual information of the graphing calculator may be harder to process than one might think.

**INPUT and OUTPUT (feedback)** (CALCULATOR … especially the Graphing Calculator)
A calculator uses "cryptic" input methods … numbers are usually typed, but other information is accessed through a menu structure. Some research showed that a menu-based input was less effective for learning, compared to input that was fully typed; see Corbett, et al. Although this research was based on computer interaction, I believe that the same effect might be found with calculators. (The reason is the

'phonological priority' in short-term memory, and semantic priority for long-term memory, discussed above.)

Another factor in learning based on technology, calculator and computer, is "speed of feedback". We see this as an advantage, when it might be a disadvantage. Research has suggested that "immediate feedback" can be a negative factor in learning (see Schooler). The rationale for this effect is that the immediate feedback competes with the learning content for the resources in working memory … paying attention to feedback means that there is less attention available for the concepts and procedures.

Simply being "fast" may be a problem as well. When learners complete activities quickly, research shows that the entire process tends to stay in working memory … never making the transition to long-term memory. See O'Reilly (page 153), Leron (online) and Kahneman (online). [These last two references are from psychology, not education; strictly speaking, they indicate that quick activities stay in the "S1 processor" which in intuitive and habitual – as opposed to the "S2 processor" which involves judgment and application of criteria. These concepts are parallel, though very different from, working memory and long-term memory.]

**EFFECTIVENESS** (CALCULATOR … especially the Graphing Calculator)
As with any tool used in learning, care needs to be taken that the tool does not become the learning. See Cole & Derry (pg 217) and Noss & Hoyles (pg 390). Noss & Hoyles make the point that the "tool is not transparent" … tools always change the nature of the task; the calculator represents the mathematics in a different way – and that impacts the learning.

Clearly, there have been numerous research studies on calculator usage; unfortunately, these studies tend to be flawed technically. The soundest research summary is that calculator usage did not lower performance on skills test, may have slightly improved conceptual results, and might have slightly improved problem solving (Ellington, pg 449-455).

**Summary:** We can improve the learning effectiveness of the calculator by always connecting the results back to symbolic or verbal representations, by encouraging students to articulate while using it (creating phonological information), and by suggesting a slower pace. (Learning probably works better when NOT played at the same speed as a fast-paced game.)

## ONLINE LEARNING

"Online Learning" here refers to a restricted use of internet – the delivery of the entire "course" online, not simply delivering content online. Other online technology is discussed below.

One interesting research result related to the instructional design of online learning environments. Designers often try to accommodate different learning 'styles' by providing the complex design; studies consistently show a lower level of learning and lower transfer for these complex designs (see Bruning pg 221). A 'simple' visual presentation with narration works better than a complex multi-media presentation with on-screen text and narration. (The simple visual with narration makes use of both the visual channel and auditory channel (in working memory) since they have independent capacities, without overloading either 'channel'.) Although there are no absolute standards for "simple" and "complex", designers should use the simplest presentation that can achieve the outcome desired.

One source provided some 'standards' for e-learning (online); see Stahl et al, pg 410.

(1) Posting content does not make for 'compelling instruction';

(2) At least as much teacher effort (as face-to-face);

(3) Computer mediated collaboration is not automatic … effort & structure are required;

(4) Some collaboration could be face-to-face, such as computer supported (mediated) collaborative learning.

Though little of this would be a surprise to those who teach online routinely, the list is helpful to our thinking. Stahl et al discuss computer mediated collaborative learning in detail.

## OTHER TECHNOLOGY

Wireless learning technology ("WILD", from Wireless Interactive Learning Devices) may be the next technological "frontier". Pea and Maldonado describe some applications; in particular, networked handheld devices have been used in classrooms. A limitation exists for mathematics – graphing calculators generally will not have built in wireless capability, since that would preclude their use on standardized tests (SAT, ACT, etc). Hewlett-Packard has a calculator with a built-in infrared port (online link provided in references). Texas Instruments markets a networking device (TI Navigator); neither TI nor Casio appear to have any plans to make calculators 'wireless'.

Online learning tools are becoming very popular and flexible (using Java and occasionally other technologies). The Shodor Foundation (Panoff reference) has a web site providing numerous free tools.

Tutorial technology has become complex. One tutorial system is especially relevant – the Cognitive Tutors are available for algebra, have been shown effective, and are based on one of the most researched learning theories ("ACT-R"). See Koedinger pages 64-67 for the research; the software is marketed by Carnegie Learning (online link in references).

The Knowledge Forum is another tool being used in a variety of settings (marketed by Learning in Motion; see references). The Knowledge Forum is a creative tool for developing and organizing knowledge in a collaborative, online environment.

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