Why should a teacher use technology in his or her mathematics classroom?

Research Note 8

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*Technology can reduce the effort devoted to tedious computations and increase students' focus on more important mathematics. Equally importantly, technology can represent math in ways that help students understand concepts. In combination, these features can enable teachers to improve both **how** and **what** students learn.*

Two Reasons to Use Technology: Computation and Representation

The use of technology has a long history in mathematics education. Many societies, for example, introduce arithmetic with an abacus, for two reasons. First, the abacus supports computation. Second, the abacus presents a tangible image of mathematics, which helps students understand difficult concepts.

Computation and *representation* go hand-in-hand, both historically and in the present.
For example, in primary school classrooms, many teachers use concrete manipulatives, such as Geoboards (allowing children to make geometric figures by stretching rubber bands over a grid of nails) or Dienes Blocks (providing children with a physical model of the place-value system in which "473" means four hundreds, seven tens and 3 ones). In secondary school, researchers have found that more advanced tools are necessary. These advanced tools help students learn by supporting computation and by giving abstract ideas a more tangible form. Researchers have found that whereas physical manipulatives are the right tangible form for elementary school, ICT-based tools are the right tangible form for secondary school (Kaput, 1992; Kaput 2007).

Researchers have found that ICTs can support learning when appropriately integrated with teaching techniques, curriculum, and assessments (Means & Haertel, 2004). Thus for more specific guidance, teachers should look for research on integrated use of ICTs in mathematics teaching. In this research brief, we discuss two elements of successful integrations: focusing student thinking and making ideas tangible.

Focusing Student Thinking

All people face limits in the number of levels or details they can keep track of during problem solving. In addition to the unavoidable difficulty of a particular math problem, learners may experience additional *cognitive load* (i.e., thinking difficulties) in the materials and tools they use. Teachers should minimize load that is unimportant to the current learning goal and direct student activity to thinking that is germane to what they should be learning (Sweller, 1988). Technology can be useful to the extent it focuses student thinking in ways that are germane, not extraneous.

What is important or germane depends on the math topic and age of the student. In primary school, it is important to learn to do arithmetic fluently. Using technology to do this thinking for the student would be inappropriate. In secondary school, however, students have mastered arithmetic and should be focused on more advanced skills and concepts. Computational support for lower-order details can then be very important.

For example, researchers have found that when calculators are available to offload details computations, teachers can better focus on (Burrill et al., 2002; Ellington, 2003):

- More realistic or important problems.
- Exploration and sense-making with multiple representations.
- Development of flexible strategies.
- Mathematical meaning and concepts.

Modern ICTs not only handle arithmetic detail; they can also handle the detail of graphing, transforming algebraic expressions, computing geometric properties, and more.

Making Ideas Tangible

Piaget discovered that children first develop ideas concretely and later progress to abstractions (Piaget, 1970). In designing learning environments, it is often helpful to apply this principle in reverse: to help students learn an abstract idea, provide them with more tangible visualizations. For example, it is easier to see how the variable *m* in f(x) = mx + c represents a rate of change when the function is graphed and students can explore the connection between *m* and the gradient (slope) of the line (Roschelle et al., 2007).

Although drawings on paper or on the teacher's board can make ideas tangible, static drawings often fail to convey math principles. For example, many students think a triangle is an isosceles triangle if it looks like one and do not understand how to establish the property formally. With an ICT-based geometry tool, students can grab and drag a corner of a geometric construction of a triangle and see how it behaves under transformations. Playing with this tangible image can prepare students to understand the formal proof, which is much more abstract.

Researchers have found that when technology makes abstract ideas tangible, teachers can more easily (Bransford, Brown, & Cocking, 1999; Roschelle et al., 2001;diSessa, 2001):

- Build upon students' prior knowledge and skills.
- Emphasize the connections among mathematical concepts.
- Connect abstractions to real-world settings.
- Address common misunderstandings.
- Introduce more advanced ideas.

Teaching Mathematics Better and Teaching Better Mathematics

As discussed in other research notes in the series, integrating technology into the classroom can improve mathematics teaching. In addition, teachers can use technology to introduce better mathematics (Roschelle et al., 2000). For example, teachers can focus less on memorizing facts and performing routine calculations and more on developing ideas, exploring consequences, justifying solutions, and understanding connections – the real heart of mathematics (Heid, 1988). In addition, teachers can introduce more advanced mathematical topics earlier. Both the opportunity to teach math better and to teach better math should be considered in school technology plans and teacher professional development.

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