Educational technologies are those that are used “as a tool” to enhance the teaching and learning process across all subject areas … dealing primarily with information and communication technology centered around the didactic practice of using technology to improve the teaching and learning process” (Dugger & Naik, 2001, p. 32). In an earlier definition, the Association for Educational Communications and Technology (AECT) framed educational technology more broadly as “theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning” (Seels & Richey, 1994). Of particular interest here are educational technologies that are used in mathematics and science education in the middle grades.

Why use educational technologies in mathematics and science classrooms?

- Technology integration is written into national education standards:
  - The National Educational Technology Standards (NETS) describe required proficiency in both technologies for learning and technologies that increase productivity.\(^1\)
  - The National Science Education Standards (NSES) for grades 6–8 link technology use to inquiry-based learning pedagogies.\(^2\)
  - The National Council of Teachers of Mathematics (NCTM) addresses technology integration within their Principles and Standards for School Mathematics.\(^3\)
  - The Individuals with Disabilities Education Act (IDEA) requires special education services that include assistive technology.\(^4\)

- Technology integration, when combined with appropriate pedagogies, provides additional opportunities for learning and understanding.
  - Technologies, if used in pedagogically sound ways, can make the learning experience more relevant, challenging, integrative, and exploratory (i.e., Guerrero, Walker, & Dugdale, 2004; Nicol & Boyle, 2003).

- Technologies can support authenticity in problem-solving contexts (Chinn & Malhotra, 2002).
- Technologies can become cognitive tools in learning settings (Garofalo, Drier, Harper, Timmerman, & Shockey, 2000; Liu & Bera, 2005).
- Technology tools successfully support problem-based and project-based inquiry models (Barron et al., 1998; Gertzman & Kolodner, 1996; Koszalka, Grabowski, & Kim, 2002; Liu & Bera, 2005; Solomon, Allen, & Resta, 2003; van Haneghan et al., 1992).
- Technologies facilitate connecting the in-classroom experience with the out-of-classroom world, an important aspect of creating meaningful learning environments (Bransford, Brown, & Cocking, 2000; Dede, 2004; Fox-Gliessman & Kerski, 2005; Howes, Hamilton, & Zaskoda, 2003).
- For students with disabilities, assistive technologies may be the only means for interaction within a learning context (Staples & Pittman, 2003).

Which educational technologies are used frequently in constructivist mathematics and science classrooms?

Rather than attempting to list all educational technologies currently in use, this review is limited to the arguably most frequently and successfully employed technological meaning-making tools in science and mathematics classrooms.

- In a broad sense, virtual realities include microworlds, (Dede, 2004; Dede, Salzman, & Loftin, 1996; diSessa, 1986), modeling and visualization tools (Patrick, Carter, & Wiebe, 2005; White & Frederiksen, 1998), and simulations (Chinn & Malhotra, 2002; Kim, Jackson, Yarger, & Boysen, 2000). Notable examples are problem-based virtual environments, such as hypermedia, including *Alien Rescue*\(^5\) (Liu & Bera, 2005), and LeTUS curricula (Dede, Honan, & Peters, 2005; Krajcik, Marx, Blumenfeld, Soloway, & Fishman, 2000; Marx et al., 2004; Solomon et al., 2003), and *The Geometer’s Sketchpad*, a mathematical modeling environment (Flores, Knaupp, Middleton, & Staley, 2002; Garofalo et al., 2000).
• Handheld technologies include PDAs (Cwikla & Morse, 2005; Goldman et al., 2004; Parr, Jones, & Songer, 2004; Roschelle, 2003) and calculators. Both are frequently used in connection with probeware (Garofalo et al., 2000; Guerrero et al., 2004; Reid-Griffin & Carter, 2004). Calculators may also be combined with the TI-Navigator system, a wireless two-way feedback system, and used in participatory simulations (Abrahamson, Owens, Demana, Meagher, & Herman, 2003; Naismith, Lonsdale, Vavoula, & Sharples, 2004; Roschelle, 2003). An additional wireless handheld technology that has grown in popularity exists almost always as a one-way feedback tool: classroom response systems (Fies & Marshall, accepted).

What are the benefits of using these educational technologies in constructivist mathematics and science classrooms?

• Student engagement and motivation increase in connection with technology-supported and learner-centered investigations (Dede et al., 1996; Flores et al., 2002; White & Frederiksenn, 1998).

• As a result, these investigations bring about improved qualitative understanding and mathematical or scientific reasoning (Goldman et al., 2004; Parr et al., 2004; White & Frederiksenn, 1998; Wiske, Franz, & Breit, 2005).

• Students benefit from dynamically linked multiple representations by having a variety of ways to interact with concepts (Dede et al., 1996; Flores et al., 2002; Garofalo et al., 2000; Patrick et al., 2005; Roschelle, Kaput, & DeLaura, 1996).

• Classroom response systems, participatory simulations, and PDAs can provide graduated levels of anonymity and immediate feedback that benefits both teachers and learners (Fies & Marshall, accepted; Naismith et al., 2004; Roschelle, 2003).

• While tools that support cognitive processing and share cognitive load are important early in the problem-solving process, tools that support cognitive activities, hypothesis generation, and testing are important in later stages of problem-solving (Liu & Bera, 2005).

NOTES

1 For more information, see http://cnets.iste.org/
2 For more information, see http://newton.nap.edu/html/nses/6d.html
3 For more information, see http://standards.nctm.org/document/chapter2/index.htm
4 For more information, see http://www.ed.gov/policy/speced/guid/idea/idea2004.html
5 For more information about Alien Rescue, see http://jabba.edb.utexas.edu/liu/aliendb/HOME.HTM

REFERENCES


REFERENCES (continued)


REFERENCES (continued)


ANNOTATED REFERENCES


The text reviews findings of learning research across fields and age groups, and proposes a framework of learning that is defined by four dimensions of centeredness. These are: (1) learner-centeredness that begins with where learners’ understandings are at the onset of an instructional event; (2) knowledge-centeredness that makes use of existing knowledge structures to develop deeper and connected knowledge; (3) assessment to support learning, and specifically formative assessment practices that tap into developing understandings, provide feedback, and provide opportunities for revision; and (4) community-centeredness that includes the community of learners in the classroom as well as the community of the school and the community at large.


Wireless Internet Learning Devices (WILDs) include technologies such as response systems and PDAs that support pedagogical functionalities such as instantaneous aggregation of learner inputs. The article’s focus is on three types of WILD applications: classroom response systems, participatory simulations, and collaborative data gathering. Rather than requiring wireless connectivity to sources outside of the classroom, these are based on wireless connectivity within the classroom. Learner attention is focused on contributions from within the conceptual context of the learning environment, supporting pedagogical approaches such as peer learning models.


The author suggests the Teaching for Understanding framework as a rationale for selecting and using learning technologies. As such, technologies need to support generative topics, understanding goals, performances of understanding, ongoing assessment, and reflective collaborative communities. When they do provide such support, technologies promote more meaningful educational experiences.


**RECOMMENDED ONLINE RESOURCES**

http://www.marcopolo-education.org/home.aspx MarcoPolo internet content for the classroom


http://curry.edschool.virginia.edu/go/frog/home.html Net frog (Virtual Frog Dissection)

http://www.energyquest.ca.gov/index.html Energy quest

**AUTHOR**

*Carmen Fies* is an assistant professor in the Department of Interdisciplinary Learning and Teaching at The University of Texas at San Antonio. She is the Instructional Technology Program Coordinator for undergraduate and graduate studies.

**CITATION**