

Keengwe, J., Onchwari, G., & Wachira, P. (2008). The use of computer tools to support meaningful learning. *AACE Journal*, 16(1), 77-92.

The Use of Computer Tools to Support Meaningful Learning

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This article attempts to provide a review of literature pertaining to computer technology use in education. The authors discuss the benefits of learning with technology tools when integrated into teaching. The argument that introducing computer technology into schools will neither improve nor change the quality of classroom instruction unless teachers and educational leaders are able to evaluate and integrate the use of that technology into the curriculum (Geisert & Futrell, 2000) is provided by a synthesis of a review of literature across three specific areas: (a) benefits of computer technologies; (b) meaningful learning, and (c) computers and instruction.

Although different technologies such as moving film projectors, radio, instructional television, cassette players, and Video Cassette Recorders

(VCRs) have been used in the classroom, it was not until the 1970s that the personal computer found its way into schools (Sharp, 2006). In the 1980s, videodiscs, laser printers, and more VCRs emerged, and the number of personal computers increased, with scanners, CD-ROMs, digital cameras, and the Internet adding to the list in the 1990s (Pett & Grabinger, 1995). Since then, investments in educational technologies have increased on many campuses (Cuban, Kirkpatrick, & Craig, 2001; Ficklen & Muscara, 2001) in the hope that teachers could integrate them into their classroom instruction to enhance student learning. However, reports indicate that teachers are not using technology in ways that could make a difference in teaching their students (Anderson, 2001). Further, there is an alarming gap between educational technology's presence in higher educational institutions and its effective integration into classroom instruction (Cuban, 2001).

Educational technology has not changed the face of teaching and learning on our campuses (Green, 1998). Green contended that several years after the arrival of the first microcomputers on campuses, and more than a decade since the era of computer revolution in education, integration of these tools into classroom instruction remains to be seen. While access to computers for instruction has increased tremendously on American campuses (Green, 2001), the majority of teachers have not effectively integrated appropriate computer tools into their daily classroom instructional practices. Cuban (2001) claimed that teachers use computers less frequently and in limited ways that do not support student learning. Cuban wrote:

Furthermore, most professors conduct their research, produce publications, communicate in their scholarly disciplines, and prepare for teaching through electronic means. Yet when it comes to teaching, few close observers would deny that most professors are either nonusers or occasional users of computer technology in the classroom. (p. 104)

Many schools and colleges are investing more in computers because they promise new dimensions to student learning and diverse opportunities for educational reformation through technology (Becker, 2001). However, Dede (2000) lamented:

Many people see multimedia—capable, Internet—connected computers as magical devices, silver bullets to solve the problems of schools.

They assume that teachers and administrators who use new media are automatically more effective than those who do not. They envision classroom computers as a technology comparable to fire: Students benefit just by sitting near these devices, as knowledge and skills radiate from the monitors into their minds. (p. 185)

As significant investments in educational technology continue, we need to ask ourselves whether or not technology use in the classroom directly benefits student learning. While technology can play an important role in restructuring teaching and learning practices that match the current needs of an informational society (Jarvela, 2001), critics of educational technology continue to question increased funding of technology resources at the expense of teachers. Oppenheimer (2002), for instance, suggested that such funding should be redirected to support teachers' professional development programs since teachers who receive higher levels of appropriate technology training are better prepared to integrate educational technology into their curriculum (Bitter & Pierson, 2002; Yildirim, 2000).

The pressure to reform education through technology integration (Becker, 2001) and the emphasis on developing information literacy skills for students (Rockman, 2004) implies the need to support students to learn well with technology. It cannot be assumed that once educational technology tools are available, teachers will integrate them into their daily classroom instruction. On the contrary, teachers need to go beyond the common task of just providing more machines in the classroom. Fabry and Higgs (1997) stated that: "If the integration of technology in the classroom in the next ten years is to look any different from the last ten, we must focus time, money, and resources in areas that can have the greatest impact for our students, our teachers" (p. 393).

Today, educators are faced with many new challenges and responsibilities. One primary task involves determining how best to utilize available technology resources to enhance student learning. A U.S. Department of Education (2000) report indicates that:

Teachers must be comfortable with technology, able to apply it appropriately, and conversant with new technological tools, resources, and approaches. If all the pieces are put into place, teachers should find that they are empowered to advance their own professional skills through these tools as well. (p. 39)

The success or failure of technology use depends more on “human and contextual factors than on hardware or software” (Valdez et al., 2000, p. 4.). Integration of technology into instruction depends a great deal on key factors, such as the contexts in which teachers interact, their beliefs, and their attitudes toward teaching and learning (Cuban, 2001). While factors such as computer hardware and software, and technical support are key to integrating technology into instruction, it is usually the factors that are personal and deeply ingrained, such as teachers’ beliefs about the instruction process (Ertmer, 1999) and the value of computing in education (Kent & McNergney, 1999) that play a big role in the way teachers generally integrate educational technology tools into instruction. Therefore, persuading teachers who are slow adopters to become serious users can be very challenging.

BENEFITS OF COMPUTER TECHNOLOGY IN EDUCATION

In educational settings, computer technologies (such as three dimensional visioning, supercomputers, minisupercomputers, mainframe computers, minicomputers, workstations, and personal computers) and the Internet have opened new pathways of learning. Thus “learning to love and work with computers must figure amongst the more obvious ‘attainment targets’ of any contemporary educational curriculum” (Littleton & Light, 1999, p. 1).

Researchers have tried to establish the relationship between computer technology use and student learning with conflicting outcomes. Russell (1999) examined several studies comparing distance and in-class learning and found no significant difference in student achievement between these two modes. However, in a study to establish the relationship between computer technology and student achievement in mathematics, Wenglinsky (1998) reported a positive correlation between computer proficiency skills and academic achievement. Students who used computers and incorporated constructive strategies reported significantly higher scores than students who relied only on computer-based drill-and-practice programs to learn mathematics. On review studies related to technology and student achievement, Sivin-Kachala and Bialo (2000) reported positive and significant gains for students who were engaged in technology-rich environments. Those students showed significant gains and achievement in all subjects, increased achievement and improved attitude toward their own learning, and increased self-esteem.

Technology is also reported to have a great impact on the learning of children with disabilities (Cohen, 1993; Sivin-Kachala & Bialo, 1996). According to Hutinger (1996), computers provide diverse tools for children with disabilities that encourage autonomous behavior as well as increase the probability that they will interact with their learning environment. Further, technology-rich classrooms utilize multimedia to increase student interactions and enhance student learning. Students can benefit by learning with technology when technology is used for complex problem solving and information-retrieving purposes (Jonassen, Howland, Moore, & Marra, 2003).

Harris (2000) observed that technology will be a significant tool to recreate learning in the 21st Century. However, educators will need to experience a paradigm shift in their vision for technology in education. Further, they need to change their beliefs in learning processes. Harris (2000) acknowledged that:

The technological revolution can be used to reframe the very nature of the educational experience, for the barriers we often faced in the past are no longer barriers, and students no longer have to be bound by time and place to learn. The tremendous technology potential will only be realized if we can create a new vision of how technology will change the way we define teaching and how we believe learning can take place. (p. 1)

There is evidence to show that computers can help students improve their performance on standardized tests (Ringstaff & Kelley, 2002), and that “student-centered approaches are better suited to fully realizing the potential of computer-based technology” (p. 2). Further, when teachers use technology as one of the many tools in the instructional repertoire and only when appropriate for completing tasks, students are less likely to become bored. In student-centered learning, faculty must become facilitators and collaborators, and instruction must move from memorization to problem solving. Therefore, to effectively teach with technology, teachers must shift their instructional practices from a teacher-centered lecture approach to a more student-centered learning or constructivist approach (Jonassen, 2000).

Technology is popular in popular schools because educators believe it can improve student learning by providing: a more active learning; more varied sensory; and conceptual modes; less mental drudgery; learning better

tailored to individuals; and, better aid to abstraction (Dede, 1998). Even so, computer tools better supports student-centered learning when the instructor is a guide (Mayer, 2001). Further, to realize the full potential of computers in education requires teachers who can integrate these tools as an integral part of teaching and make sense of these applications for their students (Tyack & Cuban, 1995).

Technology has pervaded all sectors of education prompting the need to prepare teachers who can take advantage of these important tools to enhance student learning. According to the International Society for Technology in Education ([ISTE], 2000):

Today's classroom teachers must be prepared to provide technology-supported learning opportunities for their students...being prepared to use technology and knowing how that technology can support student learning must be integral skills in every teacher's professional repertoire. (p. 2)

COMPUTER TECHNOLOGIES AS TOOLS FOR INSTRUCTION

Technology has a great potential to enhance student achievement and teacher learning, but only if it is used appropriately (Dede, 1998). Used appropriately as classroom tools, computers provide tremendous opportunities to enhance classroom instruction. Tools are extensions of our human capability (Forcier & Descy, 2002). A tool alone does not function until it is used properly.

Computer technologies, as tools, can empower students with thinking skills and learning skills, and help students to interact with complex materials (Gibbons & Fairweather, 1998). In addition, computers can help students to solve problems and think independently and collaboratively (Knapp & Glenn, 1996). Further, the use of computer technology to address realistic situations is likely to promote the integration of disciplines, foster a team approach to problem solving, and enhance individual responsibility (Singh & Means, 1997).

Jonassen (2003) suggested using technology for interactive learning to solve problems that students face in their daily endeavors. Kent and

McNergney (1999) stated that:

As in the use of other high technologies in the classroom, teachers possess the key to the success of the use of current computer technologies...but teachers must have adequate training and support to use these technologies. (p. 10)

Teachers need to gain primary technology skills in their instructional processes but they will be most successful using technology as a learning tool for their students if they can help students to move into vast domains of knowledge where they might not be experts, and “model their own learning process when they encounter phenomena they do not understand or questions they cannot answer” (Jonassen, Peck, & Wilson, 1999, p. 22).

Educational technology can be used in the classroom as an instructional tool, as a learning tool, and as a storage device (Perkins, 1992). However, in the classroom, computers are best used as instructional tools to support student learning rather than as programming devices. Zisow (2000) stated:

I am convinced that the greatest factor affecting whether a teacher does or does not use technology in the classroom, is teaching style. Technology is merely a tool. Whether it is used or not depends on a teacher’s motivation and desire to use new tools. (p. 36)

A critical issue related to technology use is that computer technology should not drive instruction (Jonassen, 2000). Rather, instruction should drive the technological tools being used. Gooden (1996) suggested that the most effective way to benefit from technology is to integrate it into the curriculum as opposed to integrating curriculum into the technology. Technology is not a substitute for good instruction; effective teachers should provide intellectually powerful and technology rich environments for students without undermining sound pedagogical practices (Anderson & Becker, 2001).

The primary concern in technology use is for teachers to go beyond technical competence to provide students with pedagogical uses and critically analyze their effective use in various contexts (Bush, 2003). Specifically, faculty must place their technical competence within broad educational goals or desired pedagogical frameworks. Bush argued that important overriding uses of these technologies should be considered when considering

infusing educational technology into the classroom: (a) increasing students' knowledge of the subject concepts and pedagogy; (b) creating opportunities for professional and pedagogical practice; and, (c) developing critical strategies to support students in their professional practice and in the use of technologies.

Reil and Becker (2000) argued that classrooms that authentically use technology should experience changes in teacher's roles, learner's roles, and the process of learning, and assessment. Reil and Becker contended that:

Teachers who assume a professional orientation to teaching are far more likely to have made high investments in their own education, to have constructivist-compatible philosophical beliefs about education to develop the instructional practices that are related to their beliefs and to integrate computers into their classrooms in ways that support meaningful thinking and the sharing of ideas with their peer. (p. 34)

A study by O' Dwyer, Russell, and Bebell (2004) explored human factors enhancing computer technology use in the classroom that include unique individual teacher characteristics such as constructivist beliefs, higher confidence using technology, and positive beliefs about the efficacy of technology. Even so, true education reform may come through teachers who develop creative strategies for using computer technology in the classroom (Pierson, 2001). Further, true education reform should focus on developing teaching strategies that complement technology use within the curriculum. Teachers need to integrate computer skills into the content areas and recognize that computers are not ends in themselves (ISTE, 2000).

Technology by itself can not change the nature of instruction unless teachers and educational leaders are able to evaluate and integrate the use of that technology into the curriculum (Geisert & Futrell, 2000; Knapp & Glenn, 1996). Technology may challenge the entire approach to the classroom experience, the essence of teaching, and the purpose of a school (Cuban, 1999), but as tools, it presents great opportunities to support student learning. The goal of education technology is to integrate technology into the classroom so its use furthers learning goals and helps students focus on the subject, not the just the technology.

COMPUTER TECHNOLOGY AND MEANINGFUL LEARNING

Jonassen et al. (1999) argued that technology, like teachers, does not teach students; rather, students only learn when they construct knowledge, think, and learn through experience. Jonassen (2000) argued that students learn from thinking in meaningful ways, and that the thinking is engaged by representing what students know in the forms required by different mindtools. Mindtools are designed to engage and facilitate critical thinking and higher-order learning (Jonassen). Further, each mindtool requires learners to organize and represent what they know in a unique way which implies critical thinking.

Computers enhance reflection and critical thinking by involving students in higher-order thinking skills such as analysis, synthesis, and evaluation (Jonassen, 2000). To learn effectively with computers, however, students must involve, among other things, their critical thinking skills. Students learn meaningfully when they learn with computers, and not about or from computers (Jonassen). Learning with technology incorporates the use of computers to help students develop higher order thinking, creativity, and research skills (Reeves, 1998). Learning with computers involves establishing an intellectual partnership with the computers to enhance meaningful learning (Jonassen).

Meaningful learning underlies two things necessary for understanding new knowledge: potentially meaningful concepts and the ability of the learner to relate the new knowledge in a meaningful way to his or her prior knowledge (Reigeluth, 1999). Based on Ausubel's cognitive learning theory, three tenets of meaningful learning include: learner's relevant prior knowledge, meaningful material, and learner choice to use meaningful learning (Novak, 1998). Further, better understanding of concepts will result from proper negotiations of meanings across links that are created with relevant prior knowledge.

According to Ausubel (1960), meaningful learning occurs when there is a personal recognition of the links between concepts; better understanding of concepts will result from proper negotiations of meanings across links that are created with relevant prior knowledge. Consequently, the most important element of meaningful learning is not so much in how information is presented, but how new information is integrated into an existing knowledge base.

Meaningful learning is contrasted with rote learning which does not allow the establishment of important links and relationships. Novak (1998) argued that meaningful learning occurs when a learning task can be related in a nonarbitrary manner to what the learner already knows. Novak believed that while rote learning may incorporate new information into prior knowledge structure, it lacks interactions, and thus, fails to support understanding of the relationships between objects. Once a learner acquires knowledge, he or she must bring to mind (activation) and establish proper relationships between the new knowledge and the prior knowledge for meaningful learning to occur.

Integration of appropriate technology into classroom practice can positively impact important dimensions of learning such as active learning, critical thinking, cooperative learning, communication skills, instructional effectiveness, multisensory delivery, motivation, and multicultural education (Barron & Orwig, 1997). According to Jonassen et al. (2003), computers can be used to support meaningful learning when technologies engage learners in five ways: (a) knowledge construction, not reproduction; (b) conversations, not reception; (c) articulation, not repetition; (d) collaboration, not competition; and, (e) reflection, not prescription (p. 15).

If used appropriately, technology offers immense opportunities to help students learn meaningfully. Pflaum (2004) offered various suggestions on the use of technology in learning that include, the focus on computer use on students who will benefit most; using computers to align standards, curriculum, and tests; using computers for assessment as much as possible; teaching students to use computer tools, but waiting until students are ready; and, coordinating what is taught within and across grade levels. Hoover (1996) offered various implications of constructivism on teaching:

- The role of teachers has to change- teachers will act as guides or facilitators to provide students with opportunities to test their current understanding of concepts taught.
- Teachers should not assume that all children understand the same way. Rather, they may need different experiences to advance to different levels of understanding. This is critical in order to exploit inconsistencies between learners' current understandings and the new experiences before them.

- Teachers should provide learning experiences that incorporate problems that are important to students, not those that are primarily important to teachers and the educational system. Group interaction should be encouraged for better understanding of concepts and give students opportunities to compare their own understanding to that of their peers.
- Teachers should give students ample time to facilitate student reflection of the new experiences for concrete knowledge building based on past and current understandings.

The use of technology and meaningful learning raises serious and significant issues as to how best we can educate our students. Although technology is an important tool for education, its appropriate use to support learning is more desirable. Grabe and Grabe (2004) suggested the active use of text, graphics, sound, or animation in the classroom to help students acquire and synthesize information—an activity that facilitates meaningful learning. Therefore, teachers should guide students to construct their thoughts through various activities that target problem solving, decision making, goal setting, managing and preventing conflict, and achievements. Technology-based environments enhance constructive interactions between learners and instructors to share meanings and develop new more powerful meanings (Novak, 1998).

Ausubel's (1960) cognitive theory on meaningful learning could help teachers to visualize the importance of organizing learning materials and presenting new ideas to learners. It also reveals the importance of inputs to learning and how anchoring new concepts into the learner's existing cognitive structure helps to make new concepts retrievable. Teachers should, therefore, strive to design learning environments that can facilitate active learning, guide the learners to learn how to learn, recognize differences in each learner, and create different learning styles to meet the needs of each learner (Brooks & Brooks, 2001). Constructivist practices are never easy, but the benefits may justify their adoption in higher education classrooms.

CONCLUSION

There is no magic solution for integration of computer technology in the classroom. While factors such as access, support, and training are prerequisites for using technology in the classroom, effective technology integration

constitutes a major change in people's lives. Such change cannot be realized overnight; even in the best of circumstances. Teachers should not view technology use as an end in itself, but a means to an end. In this context, teachers should strive to understand appropriate ways to support students to learn meaningfully in modern technology-rich classrooms.

Teaching with technology is a complex phenomenon that involves understanding teachers' motivations, perceptions, and beliefs about learning and technology (Woodbridge, 2004). Further, to be able to benefit from technology use and integration use, teachers should have a strong conviction that the use of computer technology is more efficient and effective than the use of traditional or alternative instructional strategies available for them in teaching and learning (Simonson & Thompson, 1997). Generally, teachers are more willing to use new computer technology when they have a good reason to use it (Scoolis, 1999). Therefore teachers need to be self-motivated, interested, and willing to integrate technology in their courses. Technology provides opportunities to support student learning. However, to achieve the full benefits of education technology requires strategic planning and integration of these tools into instruction that only a sense-making and skilled teacher can provide.

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Note

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