Educational Technology:
From Research to the Classroom

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INTRODUCTION

Since the mid-twentieth century, the educational use of technology in elementary and secondary schools has frequently been under the microscope. Over that time the focus and methodology of such studies have evolved considerably. The term *educational technology* has reflected this paradigm shift, incorporating multimedia and its compositional elements along the way.

In the first half of the 20th century, teachers were already using film in the classroom to support their lessons and putting up with all its attendant difficulties, such as winding it into the projector, splicing breaks and bridging the information gaps when much-spliced films jumped haphazardly from one topic to the next. With the advent of video, this became an easier and more widespread process—although it was still necessary to search for and acquire the videos from central media libraries and difficult to excerpt sections for more targeted study or review. The ubiquitous use of motion media in the classroom was already the subject of intense research in the 1970s. Then, with the advent of streaming video, "video and web-based learning environments [became] feasible for implementation in educational settings" (Ferdig, Hughes and Pearson, 1998). Today, streaming video and other educational uses of the computer represent a challenging new area of study, in which researchers are seeking to deconstruct the latest applications of computer-based and computer-assisted instruction (CBI and CAI, respectively) to determine not only "What works?" but also "Under what conditions is it most effective?"

In this paper, we will discuss a number of the relevant findings from research into the areas of educational technology in general and CBI/CAI in particular. Taking one online application as an example (DigitalCurriculum™, a product of AIMS Multimedia™), we will show how all these findings can be applied in practice. Finally, we will offer suggestions for additional investigation into the ways in which evolving technologies can further enhance learning.

MOTION MEDIA: A HISTORY OF CLASSROOM USE

The efficacy of motion media as a learning tool has been under investigation for nearly a century, and statistically significant results have been repeatedly replicated. Research has shown that people process visual information 60,000 times faster than text and that visual aids can improve learning by 400% (3M, 2001). Thus, whether as a stand-alone teaching tool, in one of its many alternative formats as laser disc, CD-ROM or DVD, or within the interactive milieu of online streaming, the value of video in educational practice has long been recognized.

In the 1980s, when videos were in widespread classroom use, teachers reported using them across the curriculum. Films of classic novels, for example, were used to support English classes. Award-winning classic movies were put to interdisciplinary purposes incorporating political science, literature and media studies. Documentaries and purpose-made educational films were being used to teach history and other curriculum subjects. Writing teachers used videos by first having their students view them, then asking them to write reports, analyses or other responses to what they'd seen (Aiex, 1988).

Video continued to gain in popularity as schools increased the level of technology available in the classroom. In the mid-1990s, according to a report for the U.S. Congress Office of Technology Assessment (Becker, 1994),

> Roughly one-half of English teachers and 80% of science and social studies teachers reported using 'video, film, or filmstrips' once or twice a month or more. A smaller but still substantial number of science and social studies teachers (but not English teachers) reported using those media on a weekly basis—about one-third. On any given day, we estimate (from tabulations shown in the NCES codebook) 5% of 10th grade English teachers and 10% of science and social studies teachers will be using video in their teaching.

In 1998, a poll of teachers indicated their belief in the value of videos as an educational tool, with 92% reporting that the use of video technology helped them to be more effective teachers and 88% that it allowed them to be more creative. At the same time, 75% found that video enabled greater student understanding of the material being presented, indicating that it is especially effective with students who learn visually. The teachers also reported its value as a motivation for students who are reluctant to study, have learning disabilities or come from at-risk populations (Miller, 1998).

Such teacher observations have been borne out by empirical study. In a research report prepared for the Bertelsmann Foundation, Reeves (1998) summarized various findings on the use of television in the classroom, noting that "Forty years of research show positive effects on learning from television programs that are explicitly produced and used for instructional purposes" (p. 2). However, he also points out that "Television is not widely [used] in classrooms because teachers experience difficulty in previewing videos, obtaining equipment, incorporating programs into the curriculum, and linking television programming to assessment activities" (*ibid*.).

Of course, when watching these media, it is important for the learner to take an active role since "active, effortful processing of television results in better learning outcomes than passive processing" (Bates, 2003). For this reason, one may readily infer that increasing interactivity on the part of the viewer will encourage learning. A series of researchers into the educational uses of video have also pointed out how the long-established value of film, video and television to education has been enhanced by its digitization for computer access due to the potential for interactivity. (See, for example, Knapp and Glenn, 1996, or Ringstaff and Kelley, 2002). Recently "A Report on the Impact of Motion Media on Adult and K-12 Learning" (Nilakanta and Ehlinger 2003) discussed video streaming, citing a 2002 study (Boster, Meyer, Roberto and Inge, 2002) into the effectiveness of video-on-demand services. The students exposed to this technology showed a 12.6% increase in achievement levels when compared with the control group.

CBI/CAI: LEARNING WITH COMPUTERS

We have mentioned the value of using computers to access and work with educational videos. According to the findings of some twenty years of intensive research into the marriage between technology and education, their value is not simply a matter of ease of access and use; it is far greater. Using computers in the classroom to supplement traditional instruction under teacher guidance increases both achievement and retention of content on the part of the learner (Cotton, 1992).

Moreover, it increases student motivation, self-confidence and self-esteem, as well as having a positive effect on students' attitudes towards learning in general. This has been evidenced in improved school attendance, lower dropout rates and increased student independence and assumption of responsibility for their own learning (Ringstaff and Kelley, 2002; for an earlier perspective, see also Cotton, 1992). A six-year study for Apple Computer, Inc., of student responsiveness in technology-rich classrooms (Sandholtz, Ringstaff and Dwyer, 1994) showed that student enthusiasm for computer use is not due to the novelty effect of the medium but is sustained over time, resulting in more attention to study, less need for teacher assistance and greater on-task student-to-student interaction. Moreover, students were motivated to excel, frequently surpassing the requirements of their assignments. A study carried out for the Office of Educational Research and Improvement (Means and Olson, 1997) also found that use of educational technology added to learners' "perception that their work is authentic and important" and promoted greater collaboration among students. This study documented dramatic changes in students who had not been successful in conventional classroom situations; such students were often among the most skillful in using the new tools and, due to their success, altered their attitudes and study habits, excelling where they had previously lagged. This motivational aspect of educational technology is of particular note in special education (Ringstaff, Yocam and Marsh, 1996).

In 2001, a CEO Forum (2001a) report corroborated these results, finding that, "When applied to well-defined educational objectives, and integrated into the curriculum by trained teachers, education technology can produce dramatic results for students." The report went on to list specific benefits:

<u>Improve Student Achievement</u>

- Improved scores on standardized tests.
- Increased application and production of knowledge for the real world.
- Increased ability for students to manage learning.
- Increased ability to promote achievement for special needs students.
- Improved access to information increases knowledge, inquiry and depth of investigation.

<u>Develop 21st-century skills</u>

- Improved basic skills (e.g., math, writing)
- Improved digital age literacy skills (e.g., technological, cultural, global awareness)
- Improved inventive thinking skills (e.g., creativity, problem solving, higher order, sound reasoning)
- Improved effective communication and interpersonal skills (e.g., writing, public speaking, teamwork, collaboration)
- Improved productivity skills (e.g., create high quality products)

Moreover, these benefits apply across the curriculum and at all grade levels. For instance, the Apple Computer study referred to above was carried out at the elementary school level. Other Apple Classrooms of Tomorrow (ACOT) researchers found "that first graders using the technology-based system demonstrated significantly greater gains compared with those receiving only traditional instruction" (Ringstaff, Yocam and Marsh, 1996). Thus, the research indicates that children in lower grades benefit greatly from educational technology. In fact, very recent findings indicate that, "Preschool children are one of the fastest growing groups to be online" (Grunwald Associates, 2003).

Nevertheless, the older the child, the more time he or she spends using the Internet. While some might predict that these young people spend their online time chatting and gaming, education is actually one of their primary online focuses. "Children ages 6–17 who are online at home ranked educational activities (such as homework, research projects, and learning not related to schoolwork) among their top five everyday uses of the Internet." Of the children studied, 20% logged "onto the Internet each and every day for educational purposes" (*ibid.*). Similarly, a study carried out for Microsoft's Anytime Anywhere Learning Program found that students spend even more time using their computers for study purposes at home than they spend in school (Walker, Rockman & Chessler, 2000):

> Even when their teachers are not utilizing computers in particular classes, students seem to be transferring and applying their computer skills at home to complete work in these same classes where computers are not used within school. … In addition, at two of three sites … students use computers at home for a wider variety of activities than they do at school.

Parents are responding to this need on the part of their children. In a recent European survey, “nearly all the parents cited education as one reason for purchasing a home computer” (Bates, 2003, p. 61).

These findings imply that an increase in the use of computers in schools would lead to more enthusiasm for the work that goes on there. In fact, research has confirmed that students want to see the Internet used more creatively, more efficiently and more frequently at school, to be assigned tasks that have more relevance to their lives and to use the Internet for educational purposes, with computers assuming roles such as those of textbook, reference library, tutor and guidance counselor (Levin and Arafeh, 2002).

When teachers begin to use technology more intensively in constructivist environments, they report that this has “led to higher levels of student motivation, interest, and engagement. Students are writing more, reported a number of teachers, both on the computer and with paper and pencil” (Ringstaff, Yocam and Marsh, 1996, p. 5). Moreover,

> The effect on students in special education classrooms was particularly noteworthy, and sometimes surprised their teachers. In one classroom, the teacher found that her special education students were more willing to read in order to complete their projects than in traditional reading groups. A preschool teacher of children with special needs reported: "Technology has literally changed the flavor of my classroom. It’s such a motivator for my special needs children, and I am getting oral language from children who were previously nonverbal … . My kids just love it! They love being in control, they develop a sense of autonomy, competence, and soon begin relating with peers, giving them a sense of belonging."
>
> (*ibid.*, pp. 5-6)

In examining the effects of implementing technology in education, it is critical to distinguish between learning *from* and learning *with* computers. Learning *from* a computer requires that the computer function as an imparter of knowledge and possess the ability to test the student’s retention of the information being imparted. This assumes a certain level of intelligence on the machine’s part, with the interaction taking place between the learner as student and the machine as teacher. Some examples of learning from technology are integrated learning systems (ILS) and intelligent tutoring systems (ITS). Reeves (1998) explains that ILS dominate the educational technology market because of features such as centralized management, built-in diagnostic and prescriptive analysis techniques, capacity to network from centralized servers, application to students with varying abilities and obvious correlation between ILS lesson content and common assessment methods. In evaluating ILS for use, it is necessary to consider whether the pedagogical approach of the software is compatible with classroom methods. Similarly, consideration should be given to whether the content of the ILS curriculum matches that of the school curriculum and whether the type of knowledge and skills and the way they are assessed on the system match curriculum assessment tasks (Parr, 2000). In contrast to ILS, ITS technology has been much less successful as a result of "the technical difficulties inherent in building student models and facilitating human-like communications" (*ibid*., p.15).

COMPUTERS IN THE CONSTRUCTIVIST CLASSROOM

For the last twenty years or so, there has been increasing emphasis on constructivist learning environments, which are intended to enable students to construct their own knowledge through participation and interaction with their environments. In constructivist classrooms, students do not parrot concepts imposed by teacher or computer (functioning as tutor); instead, with teacher guidance, they utilize the resources made available to them in order to draw their own conclusions. In this way, they are active participants in their own learning. In constructivist classrooms, learners work *with* computers in what Jonassen (1994) refers to as an "intellectual partnership" (p.4), in which computers contribute by enabling students to overcome natural limitations in such areas as memory, problem-solving and calculation while students analyze, evaluate and organize information—all tasks beyond computers' abilities.

Means and Olson (1997) found that, in constructivist environments, technology increases "the complexity with which students can deal successfully, "explaining that

> Teachers were often surprised … by how much farther [their students] could go in specific subject areas when given technology supports. Technology can both automate mundane, repetitive portions of a task and support visualizing and presenting more essential, abstract elements.

Constructivism takes into account our growing understanding of the process of cognition. "Cognitive research has shown that learning is most effective when four fundamental characteristics are present: (1) active engagement, (2) participation in groups, (3) frequent interaction and feedback, and (4) connections to real-world contexts" (Roschelle, Pea, Hoadley, Gordin & Means, 2000). In the constructivist classroom, the computer is a source of cognitive tools. Cognitive tools "help learners organize, restructure, and represent what they know" (Reeves, 1998, p. 18). Such tools include databases, electronic spreadsheets, desktop publishing and desktop video.

> Computer-based applications such as desktop publishing and desktop video can be used to involve students more actively in constructing presentations that reflect their understanding and knowledge of various subjects. … These new technologies make content construction much more accessible to students, and research indicates that such uses of technology can have significant positive effects.
>
> (Roschelle, Pea, Hoadley, Gordin & Means, 2000)

Students are not the only ones to benefit from a constructivist application of educational technology. Among the benefits to teachers are:

- Improved ability to meet student education outcomes
- Improved professionalism
- Improved instructional practices
- Increased communication and collaboration
- Improved efficiency and more constructive time spent on administrative tasks

(CEO Forum, 2001a)

Moreover, teachers cease to be the focal point of each lesson, becoming instead coaches and advisors. Computer technology supports this role by allowing teachers to work closely with small groups or individual students and "providing a readily viewable display of the student's work and the capability for the student and teacher to jointly generate, try out, and evaluate alternative approaches." Teachers also report increased technological and pedagogical skills, more collaboration with their colleagues (including cross-disciplinary projects), "contact and collaboration with external school reform and research organizations" and recognition of their contributions through participation in training and professional conferences (Means and Olson, 1997). Like students, teachers report improved morale, greater motivation and higher professional effectiveness; in addition, because they acquire new insight into students' capabilities, teachers often begin to treat them with more genuine respect, giving them more input and decision-making power in the educational process (Ringstaff, Yocam and Marsh, 1996).

Of course, principals and administrators need to support the use of technology by providing both technology and technological support as well as flexible schedules that allow teachers to develop, build on and share new concepts in teaching (Ringstaff, Yocam and Marsh, 1996). As Stone Wiske emphasizes,

> If we want new technologies to foster significant changes in the content and process of learning, we need to devise ways of changing the professional culture of teaching. Changing curriculum standards and materials, revising assessment devices and policies, supplying schools with technical infrastructure, and hiring appropriate technical personnel will all be necessary but not sufficient. We will also need to change the terms and focus of dialogue in schools to encourage talking about subject matter and learning. We will have to change the norms of professional collaboration so that observing colleagues, exchanging curricula, conducting rigorous classroom research, risking failure, and celebrating success become familiar patterns in school workplaces.

An ACOT report (Sandholtz, Ringstaff and Dwyer, 1994) notes that optimal technology integration and application requires:

- Training workshops
- Ongoing technical support
- Release time to attend professional conferences
- Time during the school day for joint planning and team teaching
- A telecommunications network that allowed interaction across sites and with project staff
- The opportunity for routine peer observations and group discussions

The authors go on to say that, “Administrators interested in creating instructional change must be willing to implement structural or programmatic shifts in the environment for teachers who are evolving their instructional outlook.”

It is important to foster goals of collaboration and initiative among teachers, especially because, as Becker and Riel (2000) have pointed out,

> Teachers who work in collaborative settings and who take the initiative to affect their teaching environment create the same settings for their students—collaborative work and student-initiated activity. … Their use of computers with students is not limited to gaining computer competence, but extends to involvement in cognitively challenging tasks where computers are tools used to achieve greater outcomes of students communicating, thinking, producing, and presenting their ideas. Data on software use and objectives for computer use suggest that Teacher Leaders recognize the features of technology that grant students access to a broader community and knowledge base beyond the walls of the classroom.

Among the many changes that are needed in schools seeking to implement educational technology in constructivist environments may well be longer class periods. “When students used technology to support their project work, it became clear that time for working on project activities needs to be extensive enough so that students can get access to their work files, make significant progress, and then store them for future work” (Means and Olson, 1997).

DIGITALCURRICULUM: A CASE IN POINT

As we have seen, time and again researchers have reached the conclusion that the educational use of both educational video and computer technology improves academic achievement. In this section we will evaluate how AIMS Multimedia’s online product, DigitalCurriculum™, corresponds to evolving best practices for integrating educational technology with the curriculum.

At the heart of DigitalCurriculum is the AIMS Multimedia library of educational videos. As has been discussed, videos created especially for the classroom are particularly effective teaching tools. The DigitalCurriculum website allows access to close to 2,000 educational videos, which are streamed over the Internet, providing easy access for teachers when planning lessons. This means that—unlike videos which must be ordered in advance and shipped to the teacher to use for a limited period of time, DigitalCurriculum videos are available to the teacher at any time, which provides the opportunity for thorough preview and preparation. Moreover, if the teacher needs to show a video later than expected or to return to it for review, it is always available.

We mentioned above that, despite its obvious value, in the past teachers have avoided using video because of the problems inherent in the medium. As just noted, video-on-demand eliminates access and scheduling problems—especially when paired with the ability to download the programs and store them for future use. It also solves some of the other difficulties we discussed. In DigitalCurriculum, videos are broken down into sections called key concepts, each of which focuses on a particular main idea or main teaching point. In this way, it is easy for teachers to find and play just the one section pertinent to subjects being dealt with in the classroom rather than having to present the entire video, or to disrupt the flow of the class while searching for the desired segments. Moreover, because the video library has been correlated to state and national standards, it is easy for a teacher to incorporate programs into the curriculum. Finally, the assessment features included in the system provide self-study quizzes created by AIMS educational writers as well as the option for teachers to create their own assessment vehicles in the assignment section of the site. If needed, it is possible for assignments to be created directly from the content curriculum correlations, thus linking both videos and assessments to the state framework.

Of course, video in itself is not enough, as has long been recognized. Edgar Dale's 1946 Cone of Experience (further described in Dale, 1969) is often referenced in the literature on instructional technology and simplified to such statements as this:

We remember:
10% of what we read,
20% of what we hear,
30% of what we see,
50% of what we see and hear,
70% of what we see, hear, and discuss,
90% of what we see, hear, discuss, and do.

DigitalCurriculum's libraries of videos, clips, photos and Encyclopedia Britannica articles—supported as they are by study guides, interactive quizzes and tests, online teacher assignments and website references (complete with a searchable current events page)—provide students with opportunities to read, hear, see, discuss and do, thus representing the ideal learning environment, with the student taking an active role.

DigitalCurriculum was designed incorporating proven pedagogical philosophy. One of its primary inspirations was John Carroll's (1963) principle of Mastery Learning, an instructional strategy grounded in the belief that all students can learn with appropriate instruction and sufficient time. Mastery Learning has many advantages, including breaking the cycle of failure, which is crucial for all learners, especially those for whom success has proved elusive. It requires clearly defined learning objectives and ensures numerous feedback loops based on small units of well-defined, appropriately sequenced outcomes. Mastery Learning uses the techniques of tutoring and individualized instruction as well as group learning situations and brings the learning strategies of successful students to a given group.

Other foundations of DigitalCurriculum's design include Benjamin Bloom's taxonomy of educational objectives (Krathwohl, Bloom and Mesia 1956; Bloom and Krathwohl 1964), Robert Gagné's systematic instructional design (1970; 1974) and Robert Mager's criterion-referenced instruction (1975). All three educators emphasized the necessity for clear teaching and learning objectives. Mager insisted that these objectives must give measurable and observable goals, stating what learners are expected to do, the conditions under which they will do it and the criteria by which their performance will be evaluated. This insistence on clear educational objectives has been recognized in the states' development of educational standards and benchmarks. In its turn, DigitalCurriculum correlates its videos to state and national standards, ensuring clear teaching and learning objectives.

Gagné expanded his recommendations to Nine Events of Instruction: (1) engage the learners' interest, (2) inform learners of the learning objectives, (3) remind learners of relevant knowledge already acquired, (4) present material to be learned, (5) guide their learning, (6) elicit performance, (7) provide feedback, (8) assess learners' performance and (9) provide opportunity for practice so that the new knowledge will be retained and retrieved as necessary.

These considerations are the antecedents of today's constructivism, which sees the teacher's role is that of guide to the learner. DigitalCurriculum offers the teacher a tool uniquely suited to the role of guide. Its assignment feature is ideal for targeted tutoring. Key concepts offer discrete, easily conquered units that the individual student can review as often as necessary, allowing each learner to control the pace of input. Where there is need for an individual student to expand the foundation of knowledge on which to build, that student can search the site for information and other resources, and the teacher can find numerous resources in the form of detailed study guides, articles and website links offering further ideas for how to supply the student with other input. DigitalCurriculum is an effective tool in both group learning situations as well individual instruction. Moreover, it offers immediate feedback in its online self-study quizzes and built-in communication options. All of its functions can be managed and overseen by administrators, as well. In this way, it acts as a perfect example of a contemporary ILS.

Yet, at the same time, DigitalCurriculum functions as a cognitive tool. Firstly, it provides a research source within its integrated Britannica articles. Additionally it allows learners to search for websites relevant to a variety of topics and up-to-the-minute current events stories as well as videos, video clips and photos. This provides them with information they must sort, analyze and organize. As they present their findings, they can use downloaded DigitalCurriculum clips and photos and Britannica articles in a variety of ways, such as in text documents, slide presentations and web pages.

As noted above, both children and teenagers with Internet access in the home will use it to further their studies. As a 24/7, anytime/anywhere application, DigitalCurriculum enables learners both to self-tutor outside of the classroom and to continue to work at home on projects begun at school.

In addition to promoting student-centered learning environments, DigitalCurriculum includes multiple teacher-training and professional development capacities: a Resources section including professional development articles, a growing library of professional development videos, online manuals, searchable knowledge bases, customizable on-site training sessions, web-based training and toll-free customer and technical support. Its focus is interdisciplinary, with the online teacher guides suggesting cross-curricular activities based on contents in videos that might, at first glance, appear to target a particular subject area only. This is just one of the ways in which DigitalCurriculum supports collaboration among colleagues. It also allows them to share assignments with other teachers in their schools and regions as well as throughout the community of DigitalCurriculum subscribers.

CONCLUSION

In “Technology: A Major Catalyst For Educational Improvement,” Dr. Gilbert Valdez wrote,

> Numerous researchers … have concluded that educational improvement and exemplary uses of technology are inextricably tied in a synergistic embrace. Both education and the use of educational technology will be less able to obtain their maximum potential unless that relationship is recognized and acted upon in a deliberate and planned manner.”
>
> (1998, p. 1)

As we know, the No Child Left Behind legislation ushered in a new era in educational practices with an emphasis on research that meets rigorous scientific standards. Educators now find themselves required to conduct and interpret these qualifying studies. For teachers who choose to integrate appropriate technology into the curriculum, as well as for administrators who support this integration, the challenge is to find and—using appropriate criteria—evaluate the efficiency of these new tools.

The studies done on the use of motion media and technology in education allow us to look at a new product such as DigitalCurriculum and make some sort of informed evaluation by deconstructing its elements. We know that educational video is a very valuable tool and that video-on-demand seems to overcome most of the problems attendant on using video in the classroom. We can also see the value of this particular system as an interactive ILS. Moreover, it functions as a cognitive tool, as well. DigitalCurriculum fosters both independence and collaboration among students in a constructivist learning environment, while promoting interdisciplinary collaboration among teachers.

However, real empirical evidence is barely beginning to emerge for the combination of video and technology in a video-on-demand streaming system. We are not the first voices calling for more research in this field. There is need for more analysis of the ways in which both students and teachers use systems of this type. It is also necessary to examine their efficacy in the various subject areas—especially in those which have been most neglected, such as social studies and language arts. Finally, and most importantly, there have been very few longitudinal studies dealing with educational technology in general and none at all dealing with video-on-demand systems. Given the increasing popularity of such systems and the positive initial teacher report they enjoy, the need for empirical corroboration is growing ever more acute.

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