Considerations in the Use of Computer Technology As An Educational Tool

Jeffery M. Hill University of North Carolina at Wilmington

Jeffery M. Hill is an Assistant Professor in the Department of Health, Physical Education, and Recreation at The University of North Carolina-Wilmington, 601 South College Road, Wilmington, NC 28403-3297.

Introduction

It seems that academia is rushing headlong into the computer revolution. Computer laboratories are proliferating on every campus. Multimedia is appearing in the classroom. Hypermedia and the Internet are buzzwords at most professional societies. Yet few are stopping to ask the hard questions about the educational efficacy of computers in the curriculum. And why should we? It's such a sexy, high-tech approach to learning that it must work wonders. Increasing technology is surely better than using that monomedia blackboard or a non-interactive textbook.

Research continues to lead us down this rosey path. Marchionini (1988) claims that multimedia enhances cognitive skills. Eckols and Rossett (1989) suggest that hypermedia facilitates individuation of the learning environment. And, very popular among many faculty, Rhoads (1988) proposes that computers can even increase student independence on course assignments. The list of research support for benefits from integrating computer technology into the curriculum seems endless.

Despite this seemingly unbending belief by many that computers are the future of education, the debate rages on. Since the earliest days of formalized instruction, academicians have been arguing about the merits of one educational approach over another. Rarely has this argument become as intense as that concerning integration of computers into the curriculum. Although most of us can accept that their introduction is a foregone conclusion, the crux of the argument is the instructional role which computers should be playing and will be playing in the future.

Yet, this argument is a misleading one. Perhaps more than any contemporary medium, computers should be viewed merely as a tool. And most relevant to the current debate, it is how this tool is used which determines its educational impact.

Computer Technology vs. Educational Technology

Before we can debate the merits of computer technology as an educational medium, it is important to discuss the terminology underlying it. Heinich, Molenda, and Russell (1985) clarify for us the foundations of the debate:

Technology - 1. A process - "the systematic application of scientific or other organized knowledge to practical tasks;" the process of devising reliable and repeatable solutions to tasks. 2. A product - the hardware and software that result from the application of technological processes. 3. A mix of process and product - used in instances where: (a) the context refers to the combination of technological processes and resultant products; (b) process is inseparable from product. (p. 402)

In the purest sense then, educational technology is not equivalent to computer-related hardware and software, although for many it is perceived to be. Educational technology is much broader. Computers are but one of many technological products which may be employed by teachers in the process of educating our students.

We must also consider that computer technology, as both process and product, is quite different from educational technology, with which we are concerned. In the latter, computer technology is but a subset. Through the use of computer technology we are attempting to solve a problem in our field: reliably and repeatably educating our students. Are computers therefore necessary and/or sufficient for education to occur? The answer of course would be "no." On the other hand, if we ask whether computers can play a role in efficient and effective educational processes and products, the answer would have to be a resounding "maybe."

Our debate over computers as an educational technology then really only makes sense in light of the third definition of technology by Heinich, Molenda, and Russell (1985). In education, we are concerned with the product of our efforts, yet the process of achieving these products is inextricably intertwined within the product. Nonetheless, for many the debate revolves instead around the second definition, which focuses solely upon the hardware and software. Perhaps this view is the reason that many have implemented computers into their curriculum with little or no tangible success: they are beginning with a potential solution (eg. multimedia) with minimal consideration of the foundations of the educational problem. In other words, they are confusing computer technology with educational technology.

To reframe the argument then into the proper perspective , we must ask what role computer technology can play as educational technology. Yet herein lies the problem: our belief in a singular generalizable "computer" that we can put under the empirical microscope to determine its educational efficacy. It is the way in which computers are used which we must consider. Computer technology today can be and is being applied in a diversity of ways within the educational context. For example, a cursory scan of the literature reveals such application types as multimedia, hypermedia, hypertext, expert system, computerbased training, teleconferencing, virtual reality, performance support system, and many others (Gayeski, 1992). Nonetheless, computer applications do not exist within a vacuum. If we are to examine the educational implications of computer technology, we must of necessity consider its utilization. Bagley and Hunter (1992) suggest that computers are typically used in three ways within the educational system: 1) as a direct provider of instruction, 2) as a supplement to other types of learning, or 3) as a tool for facilitating learning. I would also propose that they can be a subject of instruction, as well, when we are teaching about computer technology. But most problematic to our discussion is the lack of a direct tie between functionality and form. Within each of these categories, the diversity of applications are incredible: ranging from simple presentation devices to intelligent expert systems. Therefore, the argument evolves from "is computer-based instruction educationally sound" to "under what circumstances is computer-based instruction educationally sound?"

Learning From Media Comparison Studies

Over the past 70 years, media comparison studies have been the basis for determining the comparative usefulness of texts, programmed instruction, television, radio, and all other media within the educational context. However, if we have learned anything from the past 70 years, it would seem to be that "there is no compelling evidence that media cause learning increases under any conditions" (Clark, 1994, p. 25). Instead, we must consider the specific attributes of the medium, and their relationship to the educational context within which the medium is utilized. This situation is where we may begin to see educational benefits relative to specific media.

We may note that each medium possesses a specific group of defining attributes. Specifically, we can examine the attributes of any medium in terms of its technology, symbol systems, and processing capabilities (Kozma, 1991). Technology attributes in this instance are those that define the physical structure and capabilities of a medium for specific functions and forms. As Kozma (1994) notes, the technology attributes are frequently used to differentiate media (eg. a radio vs. a computer). More importantly, the attributes related to technology typically determine both the symbol systems and processing capabilities of a medium. Symbol systems of a medium are considered to be the symbolic means by which information is conveyed through that medium, such as text, photographs, animation, etc. It is in this domain that message and instructional design play a critical role. Finally, the processing capabilities of a medium are the means through which the symbol system is stored, retrieved, displayed, and manipulated.

We can now begin to fully understand why it is difficult to present a generalizable statement of the efficacy of computers in an educational context: computers vary greatly in technology, symbol systems, and processing capabilities. This fact is due not only to the hardware, but the software. Further, if we are to be consistent with our definition of technology as both product and process, we must also consider the methods in which computers are used within the educational context.

Media, Method, Context, and the Role of Constructivism

The question must then be asked whether consideration of the specific attributes of any medium is alone sufficient for determining its educational efficacy. This belief may hold true from a behaviorist, non-interactionist perspective of education wherein the dissemination of information from is unidirectional, from sender to receiver. Missing, however, from this perspective are the "cognitive, affective, and social processes by which learning occurs" (Kozma, 1994, p. 8). In essence, we must also consider educational context, as well. Theories or worldviews such as constructivism (Duffy & Jonassen, 1992) and situated learning (Brown, Collins, & Duguid, 1989) reinforce the notion that learning is active, social, and idiosyncratic, wherein motivation and predisposition play a critical role. Therefore, learner attributes must be considered, as well as media attributes.

Further, in utilizing a specific medium within a specific educational context one is also inherently utilizing an educational method, either intentionally (as we would hope) or unintentionally. Therefore, we begin to see that educational technology actually encompasses aspects of both instructional design and delivery technologies (both product and process), as well.

Can we then consider a medium, such as computer technology, in the absence of educational context and method? I believe that the answer would be "no." Each is inextricably intertwined, per our prior definition of technology. It is for this reason that media comparison studies are typically confounded. In manipulating the educational medium in a naturalistic setting, one is manipulating the method and context as well. It is therefore rarely possible to determine inarguably whether computers alone are beneficial or detrimental to the educational environment. However, we can determine what attributes of computers could be beneficial.

Matching Attributes and the Research Agenda

Based on the preceeding argument, one might be led to believe that computers are not an effective educational tool. However, that would be an ill-advised conclusion. Bagley and Hunter (1992) conclude that research support for positive impacts of computer technology upon learning are strong. Their findings suggest that educational computer technology can promote active learning, empower students, increase time spent in learning, increase enjoyment of learning, facilitate the use of additional resources, enhance problem solving and reflection, facilitate collaboration and communication with others, lead to greater independence, and promote creative and critical thinking. Such premises are supported by much other research.

Where we must be careful in is making blanket statements concerning computer efficacy. Computers can play a role in education. However, this role may not necessarily be beneficial. Therefore, our research agenda should focus upon determining how we can increase the odds of educational benefits arising through our use of computer technology. In this regard, perhaps the most powerful role of educational computer technology can then be realized when the attributes of the computer medium, as well as the method and context in which it is being used, supplement human weaknesses in learning and complement human strengths (learner attributes) (Jonassen, Campbell, Davidson 1994).

In order to examine attributes of educational computer technology, Hoogeveen (1995) has proposed an excellent paradigm. Based upon research support from perceptual psychology, he suggests that five dimensions for determining attributes of educational computer applications can be identified:

- 1. level of multimediality (the number and diversity of media encompassed)
- 2. level of human-machine interactivity (ability for the learner to control the computer system and its outcomes)
- 3. level of congruence of information types used (degree to which information is redundantly presented through diverse media types)
- 4. usage of reference models (meaningful organization of information)
- 5. quality of representation (fidelity of media)

Although in the early stages of empirical utilization and verification, Hoogeveen (1995) proposes that effective educational computer systems exhibit a high degree of multimediality, interactivity, congruence, reference model usage, and representation quality. Yet, caveats do emerge. Multimediality may play a more important role in the perception of enjoyment of the educational process than learning itself. Increased learner control in interactivity does not necessarily equate with enhanced learning, as some users do not possess the necessary skills for self-directed learning within this context. Finally, representation quality may play a greater role in learning when the task itself depends upon it (eg. reading or object recognition). Nonetheless, Hoogeveen's model does provide us with the basic framework for researching media attribute decisions regarding instructional computer usage.

In order to determine learner attributes, we must turn to the expansive (and often conflicting) literature on teaching and learning. McKeachie's (1994) survey of the literature suggests that attributes of effective learners include:

- 1. organization
- 2. ability to develop and apply broad principles and concepts,
- 3. seek active learning
- 4. ability to adapt existing and develop new cognitive learningstructures.

Remaining within the same corpus, we must then seek out attributes of effective method. Based upon an analysis of research by the American Association of School Administrators (1986), effective teachers:

- 1. Tend to be good managers
- 2. Use systematic instruction techniques
- 3. Have high expectations in their students and themselves

- 4. Believe in their own efficacy
- 5. Vary teaching strategies
- 6. Handle discipline through prevention
- 7. Are usually warm and caring
- 8. Are democratic in their approach
- 9. Are task-oriented
- 10. Are concerned with perceptual meanings rather than facts and events
- 11. Are comfortable interacting with students
- 12. Have a strong grasp of the subject matter
- 13. Are readily accessible to students outside class
- 14. Tailor their teaching to student needs
- 15. Are highly flexible, enthusiastic, and imaginative

Finally, we must be sure to examine instructional method and contextual attributes. According to Collins (1991), there seem to be consistent trends among schools which have successfully integrated computer technology:

- 1. A shift from whole-class to small-group instruction
- 2. A shift from lecture and recitation to facilitation and coaching
- 3. A shift from working with better students to working with all students
- 4. A shift toward more engaged students
- 5. A shift from assessment based on test performance to assessment based on products, progress, and effort
- 6. A shift from a competitive to a cooperative social structure
- 7. A shift from all learners learning the same things to different students learning different things
- 8. A shift from verbal thinking to the integration of visual and verbal thinking

The agenda for research, then, is to examine the attributes of media, learner, method, and context for areas wherein each can reinforce effective and efficient instruction, particularly wherein technology play a unique role. It must be recognized that the resultant educational processes may be quite disparate from current practice, particularly in the use of educational computer technology. Nonetheless, once research has provided guidance and grounding, we still must consider whether faculty will integrate computer technology into the educational curriculum.

Organizational Integration: A Caveat

Given the potential then for integrating computer technology into a curriculum based upon grounded research, one must wonder why only half of all U.S. teachers have used a computer at all (Maddux, Johnson, & Willis, 1992), and as few as 2 to 3 percent of university faculty utilize multimedia technology in the classroom (Sammons, as cited in Yaverbaum & Reisman, 1995). Five critical factors in successful integration of technology have been identified by Stockdill and Morehouse (1992). We have previously addressed four of these: educational need, user characteristics, content characteristics, and technology considerations. However, most relevant to the current discussion, we must also consider organizational capacity. To Sammons (as cited in Yaverbaum & Reisman, 1995), the three elements of organizational capacity which are most restraining are equipment, time, and knowledge. Equipment is becoming less of an issue as prices of computing equipment fall while power of the systems rises. Yet, at the same time, university budgets more frequently come under scrutiny. Nonetheless, time and knowledge continue to be limiting factors to educational integration of computer technologies (Elliott, Jones, Cooke, & Barker, 1995).

Developing computer-based instruction requires large investments in time. It has been estimated that it takes between 100 and 150 hours to develop one hour of hypermedia-based instruction (Christie, 1990). Is it any wonder that so few do so? For example, even among computer literate staff at the University of North Texas, Rode and Poirot (1989) found that even of the "computer literate" faculty, 65% would not author educational software.

Faculty knowledge can be considered from several perspectives (Cummings, 1995). First, most faculty did not learn to use, were not trained in, and frequently did not even experience educational computer technology in their professional preparation. Among thos faculty who do use it, most have learned to do so of their own volition, above and beyond their "traditional" duties (which again brings us to the limitation of time). This situation is compounded by the lack of support staff for these activities. Therefore, most faculty do not use such technologies, and many who do make little progress. Second, most faculty do not have the instructional design knowledge and/or requisite time to be able to adequately integrate computer technology into instruction. Such integration typically requires curricular revision in order to take advantage of the technology. Many researchers have found that educational computer technologies are more likely to be adopted and utilized when curricular revisions are not required or implemented (Cates, 1992).

Sammons (as cited in Yaverbaum & Reisman, 1995), however, does not consider a primary element of organizational capacity within higher education: retention, promotion, and tenure (RPT). The reward system surrounding the use of computer technology in the curriculum is a primary factor in determining whether and how it will be used by most faculty (Cummings, 1995). It is not surprising, then, that Green and Eastman (1993) found that only 44.1% of the participating institutions support faculty development of computer-based educational technology, yet only 14.5% had developed a formalized system of rewarding faculty for development of these same resources. Given that the basis of many RPT decisions is measured in research productivity, notably refereed journal articles, it is predictable that such time-consuming tasks as development and integration of educational computer technologies frequently take a back seat.

The Upshot

The argument, then, of whether computer technology in education is beneficial or detrimental is actually misleading. Instead, we need to be concerned with the role of computers as education technology. In other words, we need to focus our efforts upon determining which educational strategies work best, and then ascertain which technologies can best support them. Nonetheless, without an adequate organizational support framework, development and integration of effective computer-based educational technology will be limited.

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