Teaching, Learning, and the Impact of Multimedia Technologies

By Tony Bates

Developments in the Internet, particularly the World Wide Web, and in multimedia technologies are resulting in new approaches to designing and developing teaching and learning in higher education. Some of the

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characteristics of such developments can be described as follows:

- An increased flexibility and access to learning, resulting in new markets being reached, particularly the life-long-learner market
- The enhancement, through multimedia technologies, of psychomotor and intellectual skills, including problem-solving and decision-making skills
- The ability, through Internet technologies, to sharpen knowledge-management and collaborative-learning skills and to design global, multicultural courses and programs

As the use of such technologies becomes more prevalent, it is important to ask to what extent, if at all, such developments change the forms and nature of knowledge.

Learning in the twenty-first century will be increasingly bound up with work and everyday life. It will be required on demand and will be organized in such a way that it fits the lifestyle and needs of individuals. Learners will seek education and training from a wide variety of suppliers around the world. In particular, learners need the opportunity to interact not only with their teachers but also with fellow students, even if they are continents apart. They need to be able to challenge and question what they are being taught, they need to be able to draw on their own knowledge and experience, and they need to be able to adapt what they learn to their own particular circumstances. In other words, education for lifelong learners needs to become more learner-focused.

Teaching and learning are two complementary aspects of education. Within learning, there are two key elements: content, which forms the "what" of learning; and skills, which describe the application of content to specific tasks, or the "how." These two elements are mirrored in teaching by the curriculum and syllabus (the "what") and the teaching methodology (the "how").

Multimedia technology affects both aspects of teaching and learning. It does this in three ways: in how it presents information; in how students interact both *with* the medium and *through* the medium with the teacher and other learners; and in how knowledge is structured within multimedia.

Presentation

Multimedia can represent knowledge in more ways than text or speech can. Multimedia combines text, audio, visual, graphic, and dynamic elements, such as animation and video. This presents learners and teachers with unique learning resources that can be used in a wide variety of ways to stimulate various forms of learning.

The most significant feature of the multiple forms of media is that they allow for the presentation of knowledge in numerous ways. Thus students can learn about abstract principles through text and can see the application of those principles through an animation or a video example. This presents the opportunity for deeper levels of understanding, particularly if the presentational qualities are fully and deliberately exploited to achieve this purpose and are combined with the potential for learner interaction.

Well-designed applications of multimedia then can do two things: they can enable learners to come to understandings more quickly than through more conventional classroom or textual media; and perhaps more significant, they can change how we come to know or to understand and hence *what* we know and understand. In other words, a learner may have an image or a mental "construction" that is far richer than an abstract verbal understanding. From an educational perspective, it is essential that learners can move confidently between concrete and abstract understandings and not become locked into one or the other. This does not happen by accident. Multimedia needs to be carefully designed to facilitate the development of this kind of thinking. Thus the role of the teacher is by no means diminished; indeed, such design requires highly skilled teachers working in teams with multimedia producers.

Interaction

Interaction is another term much beloved by multimedia designers but very rarely adequately defined or understood in an educational context. There are several kinds of interaction. The first is the interaction of the learner with the machine. As the sophistication of multimedia design has increased, so have the types and forms of interaction, although so far they have been rarely exploited in an educational context. The most dominant physical form of learner-machine interaction today in education is a very old-fashioned operation that was developed in the nineteenth century and that requires a high level of prior learning and dexterity: typing. Another primitive but very dominant form of interaction, especially on the Web, is the use of a mouse to click on "active" buttons. Other forms of interaction possible with a computer include drawing, speaking (voice recognition), gesturing, and singing. It is surprising that these other forms of interaction are still so little developed, since they would be especially useful for computer applications in schools.

Research over the years, however, has improved the design of computing systems to take into account the way humans like to interact with a machine. A critical part of the design of educational multimedia is the interface. A well-designed interface is intuitive for the learner, in that the learner can navigate easily and knows immediately what he or she is expected to do. The interface allows the learner to make responses that are appropriate to the learning context. Virtual reality offers much more profound changes in the way humans can interact with machines, but at this stage we cannot accurately identify the potential benefits (and dangers) that virtual reality holds for education.

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Human-machine interaction, though, is only the basement or foundation of interaction for learning. What matters to educators is the development of intellectual skills. Indeed, there is a distinct hierarchy of skills. In a limited number of subject areas, such as mathematics and engineering, where there are clear right or wrong answers, or clearly better answers, well-designed multiple-choice questions can be a useful means of testing for knowledge. But in general, multiple-choice questions serve the lowest level of understanding and comprehension and do not generally allow for perfectly legitimate alternative explanations or answers not previously considered by the designer of the multiple-choice questions.

Consequently, a more common form of response is the use of words or phrases, usually typed into the machine. Some teaching materials are programmed so that the computer can recognize key words or phrases and provide feedback. This can be particularly useful in language teaching. Increasing sophistication in computer-based syntax analysis and translation will result in more machine-read analysis and feedback, but the problems are challenging and have taken longer to develop than originally anticipated.

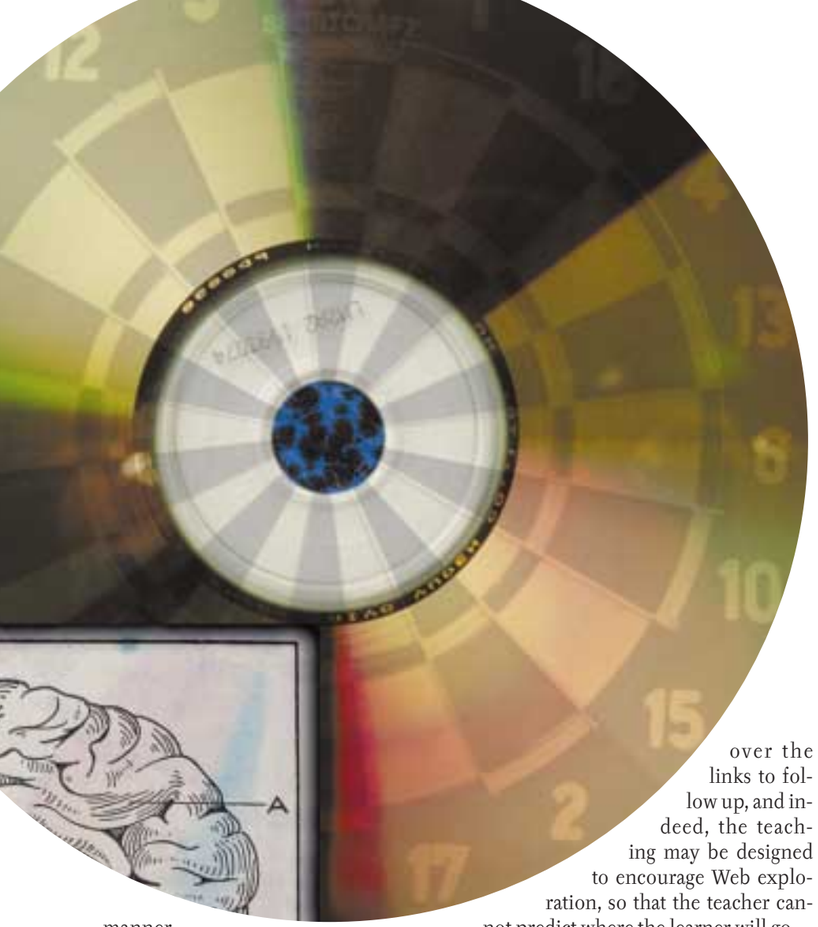
Virtual laboratories, computer simulations, and expert systems can demand from the learner much higher levels of interaction, such as analysis, problem-solving, decision-making, and evaluation. Nevertheless, in many areas of education, learners still need to discuss and argue, to challenge and question, what they have learned. Humans still are much more able than machines to deal with uncertainty, with value-laden decision-making, and with complex problem-solving. Thus, for educational purposes, it is essential to combine human-machine interaction and human-human interaction. This too can be facilitated through computer and communications technology, such as the Internet.

Structure

The third element of multimedia technologies, and the least researched or understood, is the impact on the "structure" or organization of knowledge. Both speech and text are linear in sequence. Even in text, though, structure can be complex. For instance, in a novel, the author may write about parallel actions in separate chapters or may deliberately interrupt the linear or time sequence to provide tension or incongruity in the reader's mind. The important element of text is that the writer controls the structure.

Novelists and textbook authors give a great deal of thought to the sequence and structure of their works. The reader can, of course, ignore the structure and read "out of sequence" or selectively, but that may result in a tension between the goals of the writer and the results gained by the reader. One feature of good teachers is the ability to restructure and reorganize knowledge to suit the needs of individual learners. One feature of outstanding teachers or researchers is their ability to identify patterns or structures in what would otherwise appear to be random or chaotic elements. One possible goal for a teacher is to develop the ability in students to find their own structure or understanding of the organization of an area of study.

Multimedia offers a variety of ways to structure knowledge. A CD-ROM or Web site can be structured in a linear



over the links to follow up, and indeed, the teaching may be designed to encourage Web exploration, so that the teacher cannot predict where the learner will go.

manner, just as can a textbook. Thus, a narrative text or lecture can be accessed sequentially through a CD-ROM or Web site. The medium used in the CD-ROM or Web site could be text, speech, or video, but the structure would still be linear.

However, most educational multimedia designers would feel that this is not the best use of the technology. Multimedia offers more complex and interesting ways to structure and access knowledge. For instance, the World Wide Web is based on hypertext, which links pages together. Different pages may rest on different servers around the world. Thus although a learner may start to work through the Web materials in a linear manner, at various points the learner can "take off" to other sites, explore these, and then return to the main or "home" site. In educational terms, the home site acts as a study guide, with links to many other sources of information. The learner retains more control

Multimedia materials can also be organized in an algorithmic or "tree" structure. Learners have to make a decision, and as a result of that decision the computer directs them to another area of the CD-ROM. This enables the teacher to control the sequence in which learners access materials. This can be useful if dealing with a large and complex area of study that needs to be broken down into more manageable "chunks" to prevent the learner from being overwhelmed by the large amount of detail to be covered. Furthermore, teachers can "share" this structuring of the content area by providing a "hot" index, or visual of the links between different sections of the CD-ROM. Learners can then choose where to start in the structure and the sequence to follow.

Another structure that offers interesting educational possibilities is the idea of indexed but independent learning objects. A learning object can be anything from a single graphic or log—a single slide of a physiological cell up to a simulated laboratory experiment. As well as the object, a whole set of other data will be "tagged," such as a verbal descriptor, a small fee for accessing the source, the copyright holder information, and financial transaction operations. For instance, a CD-ROM may be developed that contains a comprehensive collection of thousands of separate but computer-indexed examples of different insects. The same CD-ROM could then be combined with different Web sites and used for quite different purposes. A course on parasitology, for instance, may draw on part of the CD-ROM while a course on organic farming may draw on other parts of the same CD-ROM and in some cases may share some of the same images. Such resources are being created and stored more and more on remote servers and are accessible over the Web. A course designer then would build a teaching program with many such links integrated within the overall context, paying a very small fee (electronically) each time the learning object is accessed.

Another way of structuring multimedia is to develop a problem-based approach in which all the materials that students need to solve problems are provided but in which the materials are organized in such a way that students need to search out the necessary materials and combine them to answer problems. Thus for a forest ecology course, a CD-ROM might start with a virtual walk through the forest, with several questions or problems posed. The students would have to search the CD-ROM database to find the necessary information to solve the problems or answer the questions. The materials may be structured under discipline headings in a logical and clear way, but to solve the problems, the students need to combine information from different disciplines.

Differences in structure need to match the inherent requirements of a subject area. In addition, materials can be structured so as to suit different approaches to learning. Lastly, students' learning is likely to be influenced and guided by the structure of the materials, whether or not this is intended by the teacher or multimedia designer.

The Internet: Interaction and Power

For many teachers, the most important element of the Internet is the ability to bring isolated learners and teachers together for discussion and analysis. Thus, interaction is not so much *with* a machine as *through* it, using the technology to link people together. This enables teachers to raise topics for discussion and allows students to work collaboratively online and to submit assignments and get feedback from an individual tutor. In this context, technology does not change the nature of teaching or learning; it does, however, make learning available to those separated by time and place.

In addition, the Internet can change the balance of power and control between teachers and learners. Teachers are no longer the gatekeepers to knowledge. This shift is as profound as the impact of books on the Catholic Church. It moves the communication of learning from an authority figure informing those less powerful and informed to a context in which knowledge can be shared and reconstructed among equals. Individuals can interpret and apply knowledge to their own contexts and can share their experiences with others.

The negative side of this is the challenge to authority and experience.

Many skills cannot or should not be taught solely through technology, although the range of knowledge and skills that can be taught effectively in this way is probably much greater than most teachers would credit.

Knowledge is not evenly distributed. The teacher will know more in some areas than each individual student and, in some circumstances, more than the sum of all students in the class. This, then, raises the question of the validity and authority of knowledge gained over the Internet. How can the learner be sure of the sources of information? Even where quality and consumer control measures are in place, the game has changed, and the questioning of authority in terms of who "owns" knowledge is now a fundamental issue.

Knowledge in the Future

The future, by definition, is uncertain. But there are three possible scenarios for the future of teaching and learning.

First, the teacher will be in control. In this context, teachers and subject experts regain control. This is quite likely to happen as the Web moves from primarily a textual and graphic-based medium to a multimedia technology as bandwidth and computer power increase. Teachers can then start delivering lectures over the Internet. However, this is likely to be a short-lived triumph, since learners will be able to choose from alternative methods more suitable for distributed and lifelong learning.

Second, the technology will be in control. This would be the final triumph of artificial intelligence. Computers will diagnose the learning problems of students, direct them to appropriate sources of information, select teaching methods, provide feedback, and assess the students' work. I think this is unlikely to happen because someone has to program the computer in the first place, and knowledge not only is expanding more rapidly but also is becoming more distributed, thus making it difficult for artificial intelligence to exert control.

Third, the learner will be in control. This is perhaps the most likely scenario. Learners will take a constructivist approach to learning, seeking learning that meets their needs, in ways that are convenient, flexible, and cost-effective. In this scenario, teachers will remain important as counselors and guides, and perhaps as originators of some of the new learning materials, but they will become more like "hired hands." There is a real danger in this scenario. Learners will effectively become consumers, with the risk that short-term gain will dominate long-term benefits. Perhaps more important, knowledge will become more subjective and value-laden (what people *want* to think) and less objective and rational-deductive.

The ideal future will be a balanced future, one in which the roles of teacher, learner, and technology are all in balance and complement one another. Teachers and learners will become more concerned with the management of knowledge than with mastery of all areas. The teacher's role will combine guidance on appropriate areas of knowledge and subject matter with (especially but not exclusively in research universities) the generation of new knowledge. Above all, the teacher's role will be to challenge and stimulate the learner.

Conclusions

New technologies are fundamentally changing the nature of higher education. Nevertheless, we need to maintain a balance between face-to-face teaching and learning and technology-based teaching and learning. Many skills cannot or should not be taught solely through technology, although the range of knowledge and skills that can be taught effectively in this way is probably much greater than most teachers would credit.

The trick is to understand, first, that there are many different clients, needs, or markets for education. For some of these markets, technology-based teaching and learning is perfectly appropriate; for others, it is not. We will need to be selective and sophisticated in our decisions as to how we want to use technologies to learn and teach. Second, the roles of both learners and teachers will change, in order to exploit the benefits of new technologies. This in turn will have a major impact on our educational institutions. Third, our move to representing knowledge in various ways through technology will change the nature of our understanding. This does not necessarily mean that our understanding will be better or worse—just different.