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ABSTRACT

This paper explores the effectiveness and efficiency of multimedia-computer-based text accompanied by illustrations, graphs, simulations, and animation in teaching chemistry. The paper cautions that although multimedia may be a means to more effective teaching, there is no assurance that it increases student learning. Studies suggest that performance generally improves when the mode of instruction changes. Thus, students may initially improve their performance when a multimedia format is introduced, but this increased learning may diminish as the new method becomes the norm. The paper provides several excerpts from educational research that address this issue. Some of this research indicates also that technological integration in the classroom is initially met with great public support and student enthusiasm, but when the focus is on hardware and its abilities rather than the content and quality of instruction, learning problems occur and the technology eventually is abandoned. Well-designed packages from publishers, offering CDs and Web pages with constantly updated material that is alterable by the professor, would be beneficial. In addition, a constructivist method coupled with new technology may be more effective for long-term learning. Included are examples of instructors who have implemented effectively various techniques for increasing student learning. (Contains 10 references.) (YKH)

For Professor Theodore K. Rabb
History Department
Princeton University
Spring 1998

Multimedia
by Brian J. Pankuch

In: Issues of Education at Community Colleges:
Essays by Fellows in the Mid-Career Fellowship Program at Princeton University

Brian Pankuch
Princeton University
Spring 1998

Multimedia in Lectures and on The World Wide Web.

Abstract:
How effective and efficient is the use of multimedia for learning in lecture and on the Internet? Most results are anecdotal and show positive outcomes, with students being enthusiastic about new methods of learning. It appears that most of this effect can be ascribed to using multimedia methods students are not familiar with (Hawthorne effect). No proof was found that multimedia learning is more efficient, i.e., that more is learned during the same time spent studying. Students did spend more time with the multimedia, so they learn more due to the increased time spent not because multimedia is inherently more efficient. This does not make the additional learning less meaningful.

It does suggest that a model for developing and using multimedia should include an awareness that the effect of 'new' multimedia may be short term. Development models should include the easiest ways possible of updating substantial parts of multimedia to include the newest and best material.

My intention is to explore the effectiveness and efficiency of multimedia in teaching chemistry, particularly its use on the World Wide Web (WWW). By multimedia I mean text accompanied by illustrations, graphs, simulations, animations, etc. Hypermedia, the ability to link a given page of material with other material is generally part of most multimedia packages. I'm principally addressing the effectiveness of this technology both in lecture and on the web not the advantages of new modes of 'distance learning'.

Most of us don't have the time (or perhaps the expertise) to develop teaching packages. We can, however, preview textbooks and their supporting materials. A number of publishers are beginning to include CD's filled with material. Some include an outline of lecture notes with demonstrations and additional multimedia material. So as this is written in early 1998 we begin to have packages available so we don't have to be multimedia experts in design and general computer expert to use multimedia in lecture. We have a number options for bringing multimedia material to our lectures.

Such as using rooms set up for multimedia display, or carrying a laptop and portable projector into the lecture.

Full access to WWW plus ability to use material on a publisher's CD's in any order we wish and our own Powerpoint lecture notes would likely open a number of possibilities in learning most of us don't use now. Although there are many possibilities for how the equipment can be supplied, I'll just mention my personal preference based on 30 years of working with instruments and computers is to have my own laptop for my material. Sharing a computer for this type of work is possible but very difficult. I'd just as soon have a shared projector in my own department, again more control.

I'm basing this on recent experiences at Princeton University as well as my college where we had some problems keeping equipment working, and especially trying to get material live off the WWW.

I've tried to find well done research studies rather than anecdotal material to support or negate using multimedia and hypermedia for more effective learning. Generally I've come across of requests for massive research into how people learn. In other words we haven't proven that multimedia is more effective. Many users think it is and students appear to like it better, but do we know that it is more effective? Multimedia itself may be a means to more effective learning, by itself there is no assurance of increased learning.

Performance generally improves when the way material is presented is changed. This Hawthorne effect is known in psychology. For instance if a professors' lecture method is changed improved learning will probably occur. A 'reasonable' change causes an improvement in student learning. Students study harder when they perceive the professor is giving them attention that seems special. The increased learning falls off as the new methods become the norm. It's important to keep varying the course to keep it from getting stale. To keep experimenting to keep it a little bit new. So it is quite likely that many effects attributed to multimedia are going to be short term or ineffective as more students find it to be the norm. But are there aspects of multimedia which are more effective-learning the material long term?

Although much of what evolves below was done with K-12 in mind, most of the generalizations appear applicable at many colleges. Previous attempts to incorporate technology have been less than terrifically successful for a number of reasons:

From project 2061
Materials and Technology

> Previous technology reforms have almost always been hardware-driven and have largely ignored the content and structure of the curriculum they deliver. Therefore, the use of many technologies with potentially great educational value have followed a similar pattern: first, they are introduced with great fanfare and anticipation of the powerful impact they will have on student learning; then they are eagerly and hurriedly introduced into classrooms with little emphasis ever having been placed on examining their content or defining their

role, and even less emphasis on training teachers to properly use them; and finally, their weaknesses are soon revealed to students, teachers and parents, and they are shelved permanently, their potential power forever wasted.

... Technology and media innovation in American schools has been characterized by cyclic fads and a failure to use the sound tools and processes of science to systematically and progressively improve the quality of instruction. As we enter the 21st century, technology has become a far too powerful and valuable learning tool to allow this pattern to repeat. [1]

Just transferring age old lecture notes to Powerpoint, Astound or some other presentation software will not likely increase learning. Nor does our average student necessarily need a great deal more information, they need to learn how to use information effectively. How to use it to solve problems.

> ... For decades, cutting edge technologies have been touted as groundbreaking boons to American education. But despite the optimism that frequently accompanies the introduction of new technologies into American classrooms, research on their use in schools has found a pervasive cycle of inappropriate use followed by disappointment and abandonment (Cuban, 1986). Perhaps the main reason for the repetition of this cycle is that when instructional "innovations" that use new technologies are introduced, the focus has centered on the lure of the new hardware and its ability to process or deliver information faster, in greater quantities, and from greater distances, rather than on the quality of instruction that the hardware carries or supports. These are hardware-driven, rather than content- or instruction-driven, reforms.
>
> Hardware-driven reforms are doomed for three major reasons. First, they assume that technology alone will improve student learning, ignoring how it might actually produce affective and cognitive results. Second, because the hardware is assumed to make the difference (as opposed to the teaching or the quality of its software), new hardware tends to be introduced into classrooms hurriedly on a wave of enthusiasm and public support, but with little time and few resources devoted to training teachers to integrate the hardware into their curriculum. Third, because technology is often hurriedly introduced, its role and purpose in instruction is usually left undefined. These severe problems cannot be solved without drastic changes in current practice by the producers and marketers of hardware, in the research on educational technology, and in the ways schools select and implement hardware.[1]

We are currently in a similar rush to keep up, to do the new because our competitors are doing it. With little regard to the effectiveness other than that it is new and other colleges may be more effective in attracting students (true). Of course sometimes just being new is enough to get a positive response from students even if they don't learn material any better.

> ... Although technology was important for providing access, these results were attributed in large part to the specific combination of pedagogy and curriculum organization in the program content.
>
> ... Teachers are, therefore, put in an extraordinarily difficult position. They are often charged with designing instructional materials to accompany technologies that they are not familiar with and whose educational purpose is often ill-defined. On the occasions when staff development does take place, methods for teaching with a new technology are often prescribed by individuals far removed from the classroom, and they have little relevance for the unique needs of each teacher's classroom. [1]

So if you don't have specific reasons to use new technologies tread carefully. If you don't have a need to show material not easily produced by cheaper means why are you changing? Keeping your job because the administration wants to try is a good reason, but may not be sufficient to increase student learning.

Many uses for the same technology may occur to each of us. We may very well be able to use instructional technology in innovative ways after tweaking it to our students needs.

> ... the machine alone makes no significant contributions to student performance.[1]

Well done research on the effectiveness of an entire package plus its implementation are difficult to come by. Even packages that are effective with some test groups may be less so with our students. Using a package and trying to separate out the material which works and changing what doesn't to be more effective is challenging, but rewarding.

> ... for decades researchers have studied whether one mechanical or electronic medium produced more student learning than another, with little reference to the educational context or pedagogical or curricular content of these media. Much of this research is confounded by uncontrolled variables, rendering it invalid and not replicable. A reasonable first step in future research would be to move away from comparing technologies or methods and begin to describe carefully the science teaching and learning situations in which technology has an impact on student performance and behavior. This research-based focus on observation, analysis, and synthesis of approaches that work would at the same time meet the need to tie technology to science content and provide science teachers with specific information about how to implement technology successfully.
>
> ... Effectively used technology would have three simple distinguishing characteristics. First and foremost, technologies should provide quality education to students. There are numerous examples of effective applications of technology that not only are better than traditional approaches, but also offer unique learning opportunities. Collaboration via the Internet, real-time data collection, computer modeling, and image analysis are all examples of science learning that is either impossible or cumbersome without technology. An important distinguishing characteristic of these applications is that they focus on the specific combination of teaching and curricular organization resident in the content of the program, and on the subsequent benefits to students, rather than on the hardware that carries the application. In these examples, technology can be integrated fully into the curriculum so that all students gain an understanding of its nature, power, and limitations.[1]

A good step would be to have well researched and designed packages from publishers of the text, a combination of CD and an accessible webpage for constantly updated material. Well designed, but editable by the professor teaching the course to take account of the needs of the particular group of students at a particular institution. Training in how and why to make effective changes for different student groups would be helpful.

> ... The first and most important way in which research on the use of technology must change to support science education reform is to make student outcomes the primary measure of a program's effectiveness. Observations of teacher performance behavior, costs, and physical and social infrastructure are important in assessing a technology's

worth, but they are nonetheless secondary to that technology's ability to produce positive changes in cognitive and affective student.

Learning and teaching are going to be more deeply affected by the new availability of information than any other area of human life. There is a great need for a new approach in new methods, and new tools in teaching, man's oldest and most reactionary craft. There is a great need for a rapid increase in learning. There is above all, great need for methods that will make the teacher effective and multiply his or her efforts and competence. Teaching is, in fact, the only traditional craft in which we have not yet fashioned the tools that make an ordinary person capable of superior performance. (Heinrich, 1970, p. 56) 1 Along a similar line the "Report to the President on the Use of Technology to Strengthen K-12 Education in the United States" speaks to the need for definitive research to ascertain how people learn and how we can most effectively use technology to increase the ability to learn. Although the report doesn't deal directly with multimedia and hypermedia the call for meaningful research beyond anecdotal experience is clear.

Chaired by David E. Shaw, Ph.D.
Chairman, D. E. Shaw & Co., Inc. and Juno Online Services, L.P.
(David E. Shaw has a Ph.D. from Stanford in computer science and uses sophisticated computer modeling programs. He knows a lot about computers and what they can do.)

To some degree we need to know what we are trying to teach that goes beyond the important material of a discipline. Just facts and equations don't make the grade. Methods for learning new material has to be part of what we are teaching.

> ... it is widely believed that workers in the next century will require not just a larger set of facts or a larger repertoire of specific skills, but the capacity to readily acquire new knowledge, to solve new problems, and to employ creativity and critical thinking in the design of new approaches to existing problems.
>
> ... Initiate a major program of experimental research. The Panel believes that a large-scale program of rigorous, systematic research on education in general and educational technology in particular will ultimately prove necessary to ensure both the efficacy and cost-effectiveness of technology use within our nation's schools.
>
> ... should encompass (a) basic research in various learning-related disciplines and on various educationally relevant technologies; (b) early-stage research aimed at developing new forms of educational software, content, and technology-enabled pedagogy; and (c) rigorous, well-controlled, peer-reviewed, large-scale empirical studies designed to determine which educational approaches are in fact most effective in practice. The Panel does not, however, recommend that the deployment of technology within America's schools be deferred pending the completion of such research.
>
> ...Section 8 focuses on the need for rigorous scientific research designed to evaluate the effectiveness and cost-effectiveness of alternative approaches to the use of technology in education, on the extent to which such research should be funded at the federal level, and on the manner in which it might best be organized and administered.[2]

So here are two national studies who conclude that technology might help, but call for substantial research to find out what will work efficiently. There are lots of anecdotal stories about successes, but not controlled well designed studies. We seem to be flying blind, as to what technology works long term to increase learning. So at this point we can't say definitively that technology will increase learning. We need to do more well designed research. We can't answer the question I started with.

We are, however, under a pressure to do something with this new technology. Areas such as multimedia and hypermedia and using the Web are popular with students and administrators. Funds are usually available. If nothing else the 'Hawthorne effect', using something new should increase learning and have the usual short term effect of increased learning. I'll go a little further and hope that combined with experience, an application of multimedia and hypermedia will have some longer term effect on learning. Perhaps tying the new methods to current learning theory would be beneficial. What do we mean by learning? The constructivist learning methods are close to what we do in some chemistry labs.

> ... (students) will thus need to be prepared not just with a larger set of facts or a larger repertoire of specific skills, but with the capacity to readily acquire new knowledge, to solve new problems, and to employ creativity and critical thinking in the design of new approaches to existing problems. In the words of Frank Withrow, the director of leaming technologies at the Council of Chief State School Officers, "the US work force does not need knowers,' it needs learners.'"
>
> ... constructivists believe that learning occurs through a process in which the student plays an active role in constructing the set of conceptual structures that constitute his or her own knowledge base. [2]

We increasingly have the need to prepare students not just with the ability to solve a given set of problems. They will need to gain the abilities to use new technologies to better understand what the problem is to start with, and then discover how to solve it. So its not sufficient to know the gas laws, we need to see in a situation that gas laws could solve an inherent problem. For instance global warming is currently much in the news, but how do you measure the temperature of the globe? If it is primarily the atmosphere then perhaps we can apply the gas laws to get our estimate. There is a sizable jump between being able to plug numbers into the gas laws and being able to estimate the global temperature using these laws and experimental data. Or to judge how good are the calculations done by experts.

If simply using new multimedia hardware and software gives a transient increase learning then we need to address how do we use multimedia to be most effective. Its use must be part of a larger thoroughly researched plan. One currently popular philosophy is constructivism.

> ...Constructivist curricula often emphasize group activities designed in part to facilitate the acquisition of collaborative skills of the sort that are often required within contemporary work environments. Such group activities may offer students of varying ages and ability levels, and having different interests and prior experience, the opportunity to teach each other a mode of interaction that has been found to offer significant benefits to both tutor and tutee. Explicit attention is also given to the cultivation of higher-order thinking skills,

including "meta-level" learning the acquisition of knowledge about how to learn, and how to recognize and "debug" faulty mental models.

... the proposition that constructivist techniques, as currently understood, will in fact result in more favorable (in some sense) educational outcomes must still be regarded as largely (though not entirely) a collection of exciting and promising hypotheses that have yet to be rigorously confirmed through extensive, long-term, large-scale, carefully controlled experimentation involving representative student populations within actual schools. While the foundations of constructivism provide a rich source of plausible and theoretically compelling hypotheses, the fact remains that the question of how best to teach our children remains an empirical question that has not yet been fully answered.[2]

The combination of a constructivist method that may work well plus the effect of new technology which even if it is not more effective long term will give a boost in learning due to the 'Hawthorne" effect. Although preliminary research makes technology and constructivist approach look promising many questions remain.

... for careful research on the ways in which computing and networking technologies can be used to improve educational outcomes and the ratio of benefits to costs. The majority of the empirical research reported to date has focused on traditional, tutorial-based applications of computers. Several meta-analyses, each based on dozens of independent studies, have found that students using such technology significantly outperform those taught without the use of such systems, with the largest differences recorded for students of lower socioeconomic status, low-achievers, and those with certain special learning problems. While certain methodological and interpretive questions have been raised with respect to these results, the most significant issue may be the question of whether the variables being measured are in fact well correlated with the forms of learning many now feel are most important.[2]

Students who spend more time learning and solving problems in a given area generally do better on tests. In particular if you have created the material, such as a multimedia presentation, students using it have a better idea of what you consider important and what is likely to be on your test. A given use of multimedia or other technology may also give better results because it is new and interesting and students spend more time with it, not because it is more effective. Most of us will happily accept improved learning due to increased time spent on the material, but the multimedia will only be new for a short period of time. *If there is a truly more effective way of using multimedia -i.e., four hours spent using it shows more learning than four hours using usual methods then we have a more efficient, long term approach to learning.*

... Although some interesting and potentially promising empirical results have been reported in the literature, a substantial amount of well-designed experimental research will ultimately be required to obtain definitive, widely replicated results that shed light on the underlying sources of any positive effects, and which are sufficiently general to permit straightforward application within a wide range of realistic school environments.
... researchers, educators and software developers can be expected to develop content and techniques that optimize student performance with respect to whatever criteria are employed to measure educational attainment, progress within the field of educational technology will depend critically on the development of metrics capable of serving as appropriate and reliable proxies for desired educational outcomes.

... 1. Basic research in various learning-related disciplines (including cognitive and developmental psychology, neuroscience, artificial intelligence, and the interdisciplinary field of cognitive science) and fundamental work on various educationally relevant technologies (encompassing in particular various subdisciplines of the field of computer science).

2. Early-stage research aimed at developing innovative approaches to the application of technology in education which are unlikely to originate from within the private sector, but which could result in the development of new forms of educational software, content, and technology-enabled pedagogy, not only in science and mathematics (which have thus far received the most attention), but in the language arts, social studies, creative arts, and other content areas.

3. Rigorous, well-controlled, peer-reviewed, large-scale (and at least for some studies, long-term), broadly applicable empirical studies designed to determine not whether computers can be effectively used within the school, but rather which approaches to the use of technology are in fact most effective and cost-effective in practice.[2]

Not just the technology but how to use the technology to make learning more effective.

...The Panel also believes, however, that a large-scale, rigorously controlled, federally sponsored program of research and evaluation will ultimately be necessary if the full potential of educational technology is to be realized in a cost-effective manner. Data gathered systematically by individual states, localities, school districts, and schools during an initial phase of federally supported educational technology efforts could prove invaluable in determining which approaches are in fact most effective and economically efficient, thus helping to maximize the ratio of benefits to costs in later phases. Federal funding will ultimately also be required for research aimed at analyzing and interpreting this data.[2]

The Teaching Web: A Guide to the World Wide Web for all Teachers
Ron Owston

... As we've just seen, there's plenty of evidence that the Web is a valuable means to increase access to education. Evidence on how it can promote improved learning is not as forthcoming. In fact, there's an on-going debate in the instructional design research literature about whether there are any unique attributes of media that can promote improved learning. This debate stems from the observation that, after more than 50 years of research on instructional media, no consistent significant effects from any medium on learning have been demonstrated.[3]

Let's repeat that "after more than 50 years of research on instructional media, no consistent significant effects from any medium on learning have been demonstrated." I'm not sure what that means for multimedia, but it doesn't sound good.

... Some researchers go as far as to argue that no effect can possibly be demonstrated, because any improvement in learning that may accrue will come from the instructional design, not the medium that delivers
the instruction.[3]

Delivery of material on the Web does have some advantages, though not everyone will agree.

... there are at least three distinct learning advantages to Web use.
1. Web appeals to students' learning mode
2. Web provides for flexible learning
3. Web enables new kinds of learning

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Let's look at some actual experiments. First what is available for helping in lecture? Casanova reports using a microcomputer to project lecture material for Organic Chemistry. Note in this experiment that both groups of students spent the same time in lecture, and were tested with the same exams. The difference was the type of presentation in the lecture.

> "Students took very few notes, but listened and watched intently. Class participation (questions, comments, discussion) was high, of good quality, and stimulating. Students were very favorably impressed that they had a good understanding of the subject, particularly the visual representations of molecular structure. However, very poor performance on conventional examinations did not support this assertion. A control section (taught by Professor Stanley Pine) took all the same examinations on the same days as did the experimental section. There was a striking difference in result between the experimental section and the control section, with the experimental section performing more poorly in all categories of test items. The overall average in the course for students in the experimental section was 44%, contrasted with 63% for the control section."

Casanova, J.;"Computers in the Classroom- What Works What Doesn't"; Computers in Chemical Education Newsletter. 1996, Fall, **5-9.**[4]

What results in the best learning for our students? That we spend considerable time and effort making and using tools that may help them learn or spend the time directly with them in the more traditional methods? Of course it's not an all or nothing answer. Most of us don't have the time to go one on one with each student in person nor do we have time to become multimedia experts.

It is estimated by a number of implementors of multimedia in their lectures that a 4-6 times increase in preparation time is needed to make enriched materials. So the enriched material engaged students interest in lecture which is great, but the interest did not, in this experiment, translate into test measured learning. Plus there was a lot of time spent in developing the material.

> Engines of Inquiry: Asking the Right Questions: What Does Research Tell Us About Technology and Higher Learning?
>
> By Stephen C. Ehrmann, Annenberg/CPB Projects
>
> "I've got two pieces of bad news about that experimental English comp course where students used computer conferencing. First, over the course of the semester, the experimental group showed no progress in abilities to compose an essay. The second piece of bad news is that the control group, taught by traditional methods, showed no progress either."
>
> --from a talk by Professor Roxanne Hiltz at the New Jersey Institute of Technology on an early use of computer conferencing.[5]

Can we just assume that using technology such as multimedia is going to improve learning?

> ... they were asking whether a technology could be used to teach without specifying anything about the teaching methods involved.

Richard Clark responded to that type of assertion by arguing, in effect, that the medium is not the message. Communications media and other technologies are so flexible that they do not dictate methods of teaching and learning. All the benefits attributed by previous research to "computers" or "video," Clark asserted, could be explained by the teaching methods they supported. Research, Clark said, should focus on specific teaching-learning methods, not on questions of media. [5]

Just as unlikely that technology is going to solve learning problems by itself so is the generalization that it doesn't matter what technology you use.

... Robert Kozma argues, for example, that the particular technology used is not irrelevant, but may be either well or poorly suited to support a specific teaching-learning method. There may indeed be a choice of technologies for carrying out a particular teaching task, he argues, but it isn't necessarily a large choice. There are several tools that can be used to turn a screw, but most tools can't do it, and some that can are better for the job than others. Kozma suggest that we do research on which technologies are best for supporting the best methods of teaching and learning. [5]

Why haven't individual disciplines found breakthrough programs that make a substantial contribution to learning?

...We wanted to understand why a few software packages had proved to be viable, while so many others were not. There are many reasons for this. Support services are often under-funded, so faculty can't be certain that the basic hardware and software will consistently be available and in working order. Changing a course involves shifting to unfamiliar materials, creating new types of assignments, and inventing new ways of assessing student learning. It's almost impossible for an isolated faculty member to find the time and resources not only to do all these things, but to take all these risks. Few institutions provide the resources and rewards for faculty to take such risks. For these and other reasons, the pace of curricular change is slow.

We did discover a few small families of curricular software had found a niche. However, many of these packages gained use because they were familiar and inexpensive to develop (and thus inexpensive to update regularly). They got into use by being comfortable, not by making instructional waves. Hardly the stuff of revolution. [5]

Some of the best software is very general in nature.

..."Worldware" is the name we gave software that is developed for purposes other than instruction but also issued for teaching and learning. Word processors are worldware. So are computer-aided design packages. So are electronic mail and the Internet.

Worldware packages are educationally valuable because they enable several important facets of instructional improvement. For example, on-line libraries and molecular modeling software can support experiential learning, while electronic mail, conferencing systems, and voice mail can support collaborative learning by non-residential students.

Worldware packages are viable for many reasons: they are in demand for instruction because students know they need to learn to use them and to think with them; faculty already are familiar with them from their own work; vendors have a large enough market to earn the money for continual upgrades and relatively good product support; and new versions of worldware are usually compatible with old files, thus, faculty can gradually update and transform their courses year after year without last year's assignment becoming obsolete.

For reasons like these, worldware often has proved to have great educational potential (value) and wide use for a long period of time (viability). Has that educational potential been realized in improved learning outcomes? There is no substitute for each faculty member asking that question about his or her own students. Here are two such studies.[5]

Individual uses for the general type of software make creation of specific materials for a class more practical.

> ... he used worldware to create an animation that enabled him to teach the same material (about a complex series of interactions in biochemistry) in half an hour. The students could also study the computer-based animation outside class, frame by frame if needed. "I was initially disappointed," he told me the day I visited him at Dartmouth, some months afterward. "There was very little excitement or discussion when I showed it in class. But later, when I gave them my regular exam on the subject, they did better than any previous class."[5]

Unfortunately this experiment left out many details such is how much did the students use the animation out of class? One disadvantage of writing your own material is that although it is creative to write your own software it is an enormous time investment and the results are limited. It takes much less time using a program you are familiar with and just use it.

> ... Thus, to make visible improvements in learning outcomes using technology, use that technology to enable large-scale changes in the methods and resources of learning. That usually requires hardware and software that faculty and students use repeatedly, with increasing sophistication and power. Single pieces of software, used for only a few hours, are unlikely to have much effect on graduates' lives or the cost-effectiveness of education (unless that single piece of software is somehow used to foster a much larger pattern of improved teaching).
>
> ... 1. Technology can enable important changes in curriculum, even when it has no curricular content itself. Worldware can be used, for example, to provoke active learning through work on complex projects, rethinking of assumptions, and discussion.
> 2. What matters most are educational strategies for using technology, strategies that can influence the student's total course of study.
> 3. If such strategies emerge from independent choices made by faculty members and students, the cumulative effect can be significant and yet still remain invisible. (Unfortunately, the converse can also be true. We may be convinced that we have implemented a new strategy of teaching across the curriculum, and yet be kidding ourselves.) As usual, there is no substitute for opening our eyes and looking.[5]

Stephen Ehrmann doesn't believe it is possible to have generalizations about how new technology works in all colleges He asks if it is more appropriate to set up tools for evaluating strategy we use with our own students. Find methods that seem to work in similar colleges, then customize for our own students. He also sees big effects not just from doing something in a given class, but how it expands when something like word processing or email are used college-wide.

> Ordinarily what matters most is: - not the technology per se but how it is used, - not so much what happens in the moments when the student is using the technology, but more how those uses promote larger improvements in the fabric of the student's education, and not so much what we can discover about the average truth for education at all institutions but more what we can learn about our own degree programs and our own students.[5]

Few colleges have been willing to spend money to actually carry out evaluations of the effectiveness of using technology. There are many reasons for deciding not to do in depth evaluations. Not the least of is difficulty in making critical measurements in a fast changing environment.

- evaluation costs money and time,
- it may take months, even years, to develop a convincing picture and decisions are (always) pressing,
- changes in technology are so great that yesterday's investment in technology, no matter how successful or unsuccessful, can seem irrelevant to tomorrow's budget,
- and the possibility of meaningless or threatening findings, either of which might put the instigator at personal risk. [6]

For an opinion from Ewing at Yale Using Computers in Chemistry and Chemical Education

Computer projection can add a great deal to the presentation of technical matter and is an aide to instruction. Besides being easily produced (once the software mastered!), computer graphics often are better at holding an audience's interest than are traditional presentations. Projection is suitable for the largest lecture halls, especially with multiple TV monitors. During preparation, graphic elements are easily stored and reused, changes are easily incorporated, and external resources (images, animations, or audio) may be added. Interactive operation, including network access adds dramatic value and richness to instruction and allows instructors to adapt particular questions and problems that come up during class time.

... World Wide Web. The WWW, or "Web", offers another one-to-many communication channel. Faculty may create a set of Web pages on a Web server for class assignments or to provide needed information resources. Most Web browsing software (Netscape, Mosaic, etc.) has the advantage of handling images, animations, other types of data, and can provide a convenient "shell" (command entry system for access to other information services (FTP, gopher, telnet, news, etc.) At a sophisticated level, the Web may be used for forms-based data entry and secure transactions, which might include collecting homework, registering for sections giving exams.

... While few faculty are potential authors of multimedia textbooks, many could use the technology to prepare better lectures and materials for their own classes. Since computer software, such as Microsoft PowerPoint or Aldus Persuasion, is relatively easy to learn and inexpensive for still-projection images or to provide live media display. More elaborate tools, such as MacroMind Director or Adobe Premiere, are available for animation and video. Some faculty are writing Web pages and even using their personal computers as Web servers.

... The Automated Laboratory

The chemistry laboratory is increasingly dominated by computer-controlled instruments and digital data management, as described in other chapters. New opportunities for laboratories in education open up when laboratories are integrated with the campus computing environment. Primarily, this means giving labs full access to, and availability from, the campus data network. Lab students using personal computers or workstations can have access to information and computing resources to, for example, retrieve chemical data or literature, analyze molecular models,
perform reaction or process simulations on remote machines. [7]

From a chemistry instructor (Carolyn Sweeny)who worked with available programs.

> ... One of the programs depicts mechanisms in motion—a vast improvement over the printed page and much better than watching an instructor with waving arms attempting to show an SN2 mechanism. This software represents an excellent use of the computers provides explanations not possible on the printed page, and it doesn't grow tired as a teacher might making something move. None of the software used is very expensive some has come from the Internet freely dispensed.[8]

Russell and Kozma used a prototype multimedia computer program to teach some challenging concepts . Effectiveness was measured by giving a pretest to assess the students level and a posttest given after two lecture periods of using the computer program. Student responses were coded for content by a trained graduate assistant not involved in the design of the chemical content for this project. 34% of the students gave satisfactory answers on the pretest and 56% on the posttest. About 50% of the students showed serious misconceptions on the pretest, only 20% on the posttest.

> A prototype multimedia computer program discussed below, Multimedia and Mental Models in Chemistry (4M:CHEM), utilizes modern technology to make the classroom more interactive, stimulating, and able to assist students in building accurate mental models for chemical concepts and phenomena. The 4M:CHEM software allows students to participate in selecting experiments to test or illustrate ideas, in selecting parameters for variables in experiments, and in selecting viewing modes for observing outcomes of experiments. Both qualitative and quantitative experiments are included to assist the student in building chemical understanding and intuition as well as developing quantitative problem solving abilities.
>
> In summary, college students come into chemistry courses with an incomplete or inaccurate understanding about characteristics of chemical systems at equilibrium and about the influence of temperature and pressure on equilibrium. An initial assessment of 4M:CHEM in two lecture sections for two one-hour presentations showed an increase in students' understanding of characteristics of systems at equilibrium and the effects of temperature on these systems.[9]

Unfortunately they don't compare these results with those obtained by teaching similar students with traditional lecture methods. So learning occurred but it may be at the same rate as usual.

Roger Schank a longtime developer of multimedia feels the real potential and challenge is building systems that actively engage the user.

> Most multimedia programs fail because they merely add video and graphics to page-turning programs. It does not matter whether that next page is text, graphics, or video, because the student is not doing anything. Consider remote-controlled television, which is a type of multimedia computer.
>
> ...Creating educationally effective multimedia programs taking seriously the idea of learning by doing. Good educational software is active, not passive, and ensures that users are doing, not simply watching.

...If we wish to profoundly change education, to make our schools better and our businesses more competitive, and we recognize the value of doing this through computers, we also need to understand what it means to create high-quality educational software. Our experience in building educational software for multimedia systems led us to formulate a number of principles about how to build educational environments in schools and in the workplace:

...Learn by doing. Learning should center on a task that requires the skills and knowledge we want to teach. The task should be challenging, but within a student's ability.

...Problems, then instruction. Students respond best to instruction when what they hear from the teacher relates to problems with which they are struggling. This method will teach students to associate the correct solution with a problem they may encounter in the future.

...Tell good stories. Students respond to compelling stories. Software must have good and timely cases that relate to students' problems.

...Power to the student. The student should control the educational process. The recommended path might be marked, but students should possess the power to determine or change the next step.

...The software is the test. Since the software we are talking about lets students do certain things or discover certain answers, the test is in whether the student demonstrates a new ability or makes a discovery.

...Find the fun. An instructional designer's job is to make learning fun, which means that students will enjoy what they are doing. If the instruction was designed correctly they will learn.[10]

Find the fun, a good thought to close with.

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