different emphasis. One is based on some of the ideas in 'Peer Instruction", by Eric Mazur Prentice Hall, 1997 ISBN 0-13-565441-6.

One class is getting more short questions projected, that they try to answer. This gives me some idea of how they are understanding the topics. The second is getting more special effects with short QuickTime movies. I can project movies full screen with sound with no problem with the PowerBook. I'm also using Director animations that I've made up.

A great help has been using computer programs to generate examples live in class. For instance I'm currently going over g->mol type problems. After going over the basic ideas and definitions I project a g->mol program. Then select a problem and show the students how to do the problem using the program. The program is set up so all interaction with the user is by choosing from 4 multiple guess answers, A), B), C), or D). It has a built in tutor to walk the user through setting up a problem map or unit path then filling in step by step, with student input, each 'conversion factor' that makes up the map.

If you have set this up in PowerPoint you realize it can be very time consuming to do. Not for me I just click on a button in my PowerPoint lecture and the link starts up the program. I can show a variety of problems (random number generators give a choice of a large number of potential problems) and have step by step interaction with the class in doing the problem. I can have students hold up cards containing A), B), C), or D) to indicate their choice at a each step of the solution. This gives me immediate feedback of how each student is following the solution. The students have already been in the Mac lab and know how to use the programs, so this reinforces using the programs.

I want to reinforce this since we have been using programs for over 5 years and students who use them for more than a few hours show 2-2.5 grades higher on tests than those who don't. My projector has a zoom lens and a custom zoom (software) feature that allows me to make the program window quite large. Some of the programs have simulations available that project quite well.

The problem of students taking down every word of notes vs. others who take briefer notes, is more obvious with PowerPoint than with a board. Using chalk you have several boards to keep material up for a longer time. With PowerPoint some are getting fidgety while others are still busy writing. If you've come up with a solution to this let me know.

Note taking is helped by using computer programs that the students have access to. The students can use the programs themselves and work through similar problems- with less need to take detailed notes.

Multimedia in Lectures and on The World Wide Web. Part 2

Brian Pankuch, Editor
Pankuch@eclipse.net

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.

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 ongoing 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

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.

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.

Bibliography

1. "Project 2061 Blueprints On-Line ", American Association for the Advancement of Science, Washington, DC **1997**
URL = http://project2061.aaas.org/products/bluepol/blpframe.html

2. "Report to the President on the Use of Technology to Strengthen K-12 Education in the United States"
URL = www.whitehouse.gov/WH/EOP/OSTP/NSTC/PCAST/k-12ed.html

3. "The Teaching Web: A Guide to the World Wide Web for all Teachers", Ron Owston
URL = http://www.edu.yorku.ca/~rowstonchapter.html

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

5. Ehrmann, Stephen C. "Asking the Right Question: What Does Research Tell Us About Technology and Higher Learning?", Change 27, no. 2 (March/April **1995**): 20-27.

6. Ehrmann, Stephen C. "Gauging the Educational Value of A College's Investments inTechnology?" Available online at : http://www.learner.org/edtech/rscheval/gauging.html

7. Ewing, Martin S.;"Computing and Communications in Chemistry Education": in Theresa Zielinski, Mary Swift,(Eds); *Using Computers in Chemistry and Chemical Education,*American Chemical Society, Washington, D.C., **1997**,73-89.

8. Judd, Carolyn; Ford, RobertTeaching Organic Chemistry OnpLine—The Promise and the Reality": in Theresa Zielinski; Mary Swift,(Eds); *Using Computers in Chemistry and Chemical Education,* American Chemical Society, Washington, D.C., **1997**, 333-346.

9. Russel, Joel; Kozma,Robert; Jones,T; Wykoff,J; Marx,N; Davis,J.;"Use of Simultaneous-Synchronized Macroscopic, Microscopic, and Symbolic Reprsentations To Enhance the Teaching and Learning of Chemical Concepts": J. Chem Ed.,**1997**, 74, 330-334.

10. Shank, R.;"Active Learning through Multimedia"; *IEEE Multimedia.*,**1994**, Spring, 69-78.