Teaching sensory processes with multimedia: One of my teaching assistants is a mouse

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Experiences and lessons drawn from the author's development and use of multimedia materials in a course on sensory processes are discussed. Results from surveys of student reactions to the effectiveness of multimedia in this course identify several potential pitfalls. Issues are identified on which research is needed.

I work at a university that takes teaching very seriously but, like most universities, has not assigned a high budgetary priority to instructional technology. The computer network that spans the campus of my institution is serviceable, but it is a respectful distance from "state of the art." Ninety percent of our undergraduates live on campus, and every dormitory room is connected to the campus network. But those connections are slow, limiting the uses to which they can realistically be put. The classroom situation has not been much better: Until very recently, not one classroom at the institution was really suitable for multimedia instruction. All of this may strike technophiles as unforgivably backward. But conversations with people who teach at other institutions, large and small, suggest that the environment at my institution is not too different from those at many other schools (Gilbert, *in press*). This makes me believe that my experiences with multimedia in my classroom may be relevant to efforts planned or in progress elsewhere.

My uses of instructional multimedia are modest. They are well below what would be possible if one had unlimited dollars, infinitely elastic time, an army of support personnel, and a four-star technological infrastructure, including a high-speed network that was available everywhere, on campus and off. However, although my efforts are well below the highest of high tech, they are well above the venerable low tech of chalk and slate. My experiences with what I call "mid-tech instructional technology" may be useful to readers who are thinking about taking the plunge into multimedia. Some of what I have to say is offered as an antidote to unrealistic promises about multimedia and teaching. Some of what I have to say is advice distilled from my experiences. Two pieces of advice may be especially useful. The first is "Do not take the plunge

unless you really understand what you are letting yourself—and your students—in for." In fact, under some circumstances, multimedia can undermine your teaching and your students' learning. The second recommendation is "Do not introduce multimedia into your instructional repertoire unless you have the support and infrastructure to do it properly." As my students taught me, multimedia done poorly can be far worse than no multimedia at all.

The Advantages of Incrementalism

As an experimental psychologist, I prefer, whenever possible, to change just one variable at a time. So, when I introduce technology in a course, my preferred approach is incremental. For example, when I first implemented an electronic bulletin board in my introductory psychology course I made it optional and tested it for a limited time only. I actively discouraged technology-challenged students from using it. By talking regularly with the few hardy students who did use the bulletin board and by monitoring what they did, I spotted and addressed several problems. This was accomplished without inflicting this fledgling, flawed system on all 125 of my students over all 12 weeks of our semester. The next year, when most bugs had been exterminated, the electronic bulletin board was allowed to become an integral part of the course. Incidentally, this very simple development has had a considerable ripple effect on campus. Now, 3 years after I introduced the system, nearly three dozen courses in various departments at Brandeis are using it.

An incremental approach to instructional technology requires assessment. You have to know the success or failure of each step you take. Introducing instructional technology into a course is not like changing the color of chalk that you use. If you switch from white chalk to yellow, for instance, you can see the consequences of that switch. You might even assess the change by putting yourself in the students' shoes, sitting in various seats in the classroom to make sure that writing and diagrams were visible in your new color. But, aside from changes in visibility and changes in the color of chalk dust on your clothes, not too much can go wrong.

With simple changes, the instructor usually can tell right away if something does manage to go wrong. But

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with instructional multimedia, things are more complicated. Any one change creates a cascade of consequences. Some of these consequences will be unintended. As I will explain later, some consequences may be hidden from the instructor's view, but are all too apparent to students.

The First Day of Multimedia

I would like to claim that my work with instructional multimedia grew from some well-planned intellectual impulse firmly grounded in research on learning and memory. However, that was not the case: The stimulus was purely accidental. Two years ago, Randy Blake, who also teaches sensory processes, sent me class notes for five or six class meetings. These notes had been assembled in a Macintosh outliner program, which Randy used to pace and prompt himself during his lectures.

While browsing the notes, I saw an icon at the screen's bottom, a reminder that this outliner also had a presentation graphics mode, and some primitive drawing tools. For fun, I decided to experiment by creating part of my next lecture in presentation graphics format—just to see how it would work. By the time I quit for the night, I had learned the intricacies of the program and had made enough presentation slides for about half a lecture. This, by the way, was halfway through spring semester, 1995.

Anton Chekhov said that if a playwright hangs a gun on the wall in Act I, you can be sure that gun will be used by the end of Act III. Chekhov's comment applies to me. I put a gun on the wall by spending hours creating half a lecture. I therefore had to use that gun. So, the next day, I brought my Powerbook 160 to class, hooked it to a 17-in. display borrowed from my lab, and, while students alternately watched the display or their instructor, I used the outliner program's graphics mode to display the slides, supplementing and commenting on each in turn, and using the mouse to highlight important features on the slides. Thirty-five students viewing a single monitor was not optimal, but it was my best response to the imperative of that metaphorical gun I had hung on the wall the previous night.

The images were certainly nothing special: a motley collection of bulleted text, homemade diagrams, drawings, and imported PICT images. However, that hour was valuable to me for several discoveries, not all of them happy. First, I found that my classroom illumination had only two states: entirely on or entirely off, with no compromise between them. This created a Hobson's choice of allowing the students to see slides or allowing them to read the notes they were trying to take. Second, I discovered that my Powerbook 160 was not a good engine for multimedia. The computer took 7–10 sec to change images, even more for complex images. Ten seconds is not a long time, but when you are dealing with lots of images, 10 sec for every image is a lifetime. What's worse, the long delay made it awkward to retrace my steps, as when I had to make explicit some connection or comparison between slides several steps apart. In theory, an instructor could anticipate some places that called for retracing and then

insert duplicate slides at the right spots. Unfortunately, though, students' questions and comments demand pedagogical responses that are as unpredictable as they are urgent. Navigational flexibility is crucial if you want to exploit the technique's interactive potential. Otherwise, you have wasted hours only to build a higher tech version of a slide projector (Goolkasian, 1996).

Getting in Deeper

Despite all contraindicants, I immediately decided to convert all remaining 10 class meetings to this format, foolishly not pausing to evaluate the pedagogical impact. The staff of Brandeis's computing center was very supportive of my plan. When I explained that my Powerbook was not up to the task, they made a Centris 610 available. The computer, an LCD display panel, and an overhead projector were mounted on a cart that would be kept just 20 feet from my classroom. When I explained that it would be useful to download material to the classroom from my office and from campus servers, they established an Ethernet link in the classroom.

Even though I had taught sensory processes many times before and owned a set of very detailed notes, preparation of the multimedia materials for each lecture took 5–6 h of preparation, sometimes more. I am not the first, nor will I be the last, to discover that instructional technology is a time sink, but it is informative to consider the nature of this sink. Part of my time was "wasted" on mechanics, such as drawing, importing pictures, and developing the bullet charts. My outmoded software only made matters worse; however, since this was a trial, I wanted to make do with what I had. That was clearly a mistake. I know now that between 30% and 50% of this "wasted" time can be saved by better software, such as PowerPoint (Microsoft) or Persuasion (Abode).

I would advise anyone who contemplates this kind of activity to buy and learn the best software possible. *Best* does not mean software loaded down with every imaginable bell and whistle. *Best* means software that makes it easy to do whatever the instructor feels is important. The rest of my preparation time was spent substantially revising the flow and organization of existing material, in planning new topics and new approaches to old ones. Instructors will not want to save time here.

Some Advantages of Multimedia

Almost immediately, I found that the multimedia format had real power to help me improve my presentations. No, I do not mean the parade of colorful images or the eye-popping transition effects. I mean the ease with which you can preview and review an entire presentation very quickly. If you step rapidly through the images one after another, it is easy to spot places where an argument needs strengthening, shortening, or expanding. Also, images that are superfluous call attention to themselves, though actually deleting them can be painful (all that work down the drain). Rapid preview also makes it easier to see, almost from the audience's perspective, where steps in an

argument should be reordered. When you can review a presentation quickly and conveniently, some of the logical gaps really leap out. This may be the cognitive analogue to the well-known pop-out effect in perception (Treisman, 1986).

To encourage students to preview and review class materials, I post the multimedia presentations (including a beta version posted a day or so before class). These are uploaded to the course's folder on one of the university's servers. My course's folder, which can be accessed from any of the campus clusters or from any dorm room on campus, is also where I post e-handouts, sample exams, and pointers to reading assignments.

During a 90-min class meeting, a typical presentation includes 35–80 images, depending on how much needs to be said about each one and on how many questions are asked. For instance, an image illustrating brightness contrast needs far less commentary than does an image outlining the steps in calculating terms in a Fourier series. The images are mainly homemade, using software such as Canvas (Deneba), Photoshop (Adobe), and Excel (Microsoft), with occasional reaches for specialized programs such as NIH Image.

A typical image may present one or two bulleted talking points, a simple diagram, an anatomical drawing or photograph, illustrations of experimental paradigms, or graphs of experimental results. Successive images that deal with a common theme share a common format (color scheme, layout, etc.). This feature is less important when I work through the presentation in class than it is for students who may review the presentation on their own. The common format helps the student track the presentation's organization.

When the course reached the topic of acoustics and hearing I did the standard demonstrations: the cocktail party effect, masking, spectra of transients, reverberation, and so on. Most of these demonstrations are created with SoundEdit 16 (MacroMedia). This program allowed me to show several alternative graphic representations of the stimulus, as well as play the sound. SoundEdit 16 also let me import, edit, and combine sounds from CDs or from other sources. This year, for instance, I enhanced my demonstration of the cocktail party by electronically editing Homer Simpson's voice into the conversational din of a cocktail party (taken from a CD of sound effects). Later, my explanation of the format of a sound spectrogram exploited the deep-throated croaks of the large frogs featured in several commercials for Budweiser Beer. The one-two combination of the Budweiser frogs and Homer Simpson kept my students riveted to the topic of hearing as never before.

A Survey Produces Some Surprises

Halfway through the fall semester 1995, I decided to take stock. I developed and administered an anonymous survey of student reactions to the course's multimedia format and to the facilities we were using. The basic result was that students felt that the method had consider-

able promise but that the implementation was not very good. For example, two thirds of the students agreed with the proposition that the multimedia format enhanced the knowledge that they got from class meetings. But about half the students disagreed with the proposition that the format held their attention, that it increased their enjoyment of class, or, for that matter, that it should be used in many other courses.

Open-ended questions solicited suggestions for useful changes in both format and classroom. Here, about two thirds of the students mentioned the soporific effects of keeping room lights off during this late afternoon class. The want of a simple light dimmer was apparently undercutting my students' learning. Other answers in the survey were just as revealing. The most frequent student complaints centered on the relatively dim images generated by the LCD display and on the difficulty of taking notes. Several students wrote that graphs of data tended to whiz by before they had a chance to grasp what the graph "said." They urged me to draw graphs in real time so that they could follow more readily. This very good suggestion can be implemented by creating graphs and diagrams that reveal themselves sequentially, element by element (Stoloff, 1995).

The survey also revealed that, despite my strong encouragement, many students were not reviewing the multimedia presentations that were available on the server. In fact, nearly half the students "never" or only "rarely" used those materials. Some of the reasons for this are pretty clear. First, dorm rooms are linked to the campus network via Appletalk, which means that a student sitting down in his/her room to download a single presentation file makes a serious commitment of time. This remains true even after one of these large files is compressed. Second, students had difficulty getting access from one of the campus computer clusters. Forty percent of my students reported that three or more times during the semester they had tried to use a computer in one of the clusters but had been unable to do so because all the computers were in use. Brandeis has a reasonable number of computers in its clusters, but Brandeis students, like students everywhere, all feel the need to use those computers at precisely the same time. Third, although I do not have data on this, it is possible that students did not think it was worth reviewing the multimedia materials. After all, the files contained only images; my classroom commentary on the images was not included. I am working on ways to include some of that commentary and on techniques that will allow students to insert their questions and comments into copies of the presentations.

A Change in Venue Improves the Situation

With the student survey's dissatisfaction ringing in my ears, and just a few weeks remaining in the semester, I was very pleased to learn about a brand new classroom facility: a large lecture room for use with multimedia. The ceiling-mounted projector in the room produced very bright images from either computer or video (camera or

VCR) input, and the room's lights were on dimmers. After verifying that the images would be highly visible from anywhere in the room even with most room lights on, I immediately switched my class to this new facility.

The room was a pleasure to teach in, though there seemed to be one drawback: Students asked more questions. My hypothesis is that when room lights are off, as they were in our first classroom, the situation inhibits questions (and not only because the darkness is a soporific). After 3 weeks using the new classroom, I surveyed the students again. Their answers confirmed that the change of scenery had worked wonders. Not only did more students than before agree that the format enhanced the knowledge they got from class meetings (90% vs. 67%) but students now agreed that the facilities enhanced their enjoyment of class meetings (100%), held their attention better (93%), and made note taking easier (100%). In addition, I got some reassurance about student attitudes toward asking questions in class. I had the students express their agreement or disagreement with the following statement: "Imagine a course with the same instructor that covers the same material, but uses the standard lecture format. Compared to that course, the format of this course prevents me from asking questions during class meetings." Eighty percent of the students checked "disagree somewhat" or "disagree strongly." Only 20% checked "agree somewhat," signaling that they felt less able to ask questions. Although this is a small minority of the class, its sentiment does have to be kept in mind.

Questions Will Be Asked and Notes Will Be Taken

During class meetings, I use several techniques to encourage student participation and student questions. One approach uses slides that pose questions. For example, a series of slides may present only a portion of some experiment, challenging the students to generate the appropriate control conditions. Or a series of slides may introduce some theoretical perspective and a related experiment but require the students to generate the expected results. All of this seeks to encourage students to take what they see and hear and to process it to a reasonably deep level (Craik & Lockhart, 1972).

Like most teachers, when my students have questions, I want those questions to be asked and, if possible, answered. As I mentioned before, my survey indicated that most students, at least in the well-lit classroom, felt they could ask questions. But there is no doubt that one could devise multimedia presentation formats guaranteed to inhibit the asking of questions. For example, imagine a situation in which an unbroken series of slides presented with machine-gun rapidity communicates the unspoken message that the instructor does not want to be interrupted. The soporific anonymity of a large darkened room would make matters worse. Anyone considering the use of multimedia presentations in the classroom should also consider how those presentations would evoke and accommodate student participation.

Even if the classroom were properly illuminated—which too often it is not—multimedia makes it hard for students to take notes in class. There are a number of interesting research issues here but relatively few data, so I will speculate shamelessly. In a standard lecture, to transcribe what they are hearing, note-takers merely have to write quickly. Obviously, this stenographic approach will produce neither good notes nor good learning, but it will produce a record of what was said. However, with instructional multimedia, the stenographic approach becomes even more inadequate. Here, a good deal of the information comes through the eyes, not the ears. At a minimum, this requires an additional step of translation; at a maximum, it requires students to learn new note-taking skills, akin to those of a good reporter. The student must learn to integrate what is heard with what is seen and then summarize the products of that integration. Some of my students approached the problem in an interesting way. They decided to reproduce whatever they saw, making fairly faithful copies of the images. Although I have not yet collected data on this, I suspect that copying the images leaves few cognitive resources for other things, such as thinking about what the instructor was saying. Copying the images could even preclude thinking about what is being copied.

Some Closing Observations

Despite all the effort I have invested during 30 years of teaching sensory processes, I now spend far more time preparing for each lecture than I have ever spent before. There is little doubt that even the most modest venture into educational multimedia puts demands on faculty time that nonparticipants cannot begin to imagine. My advice to anyone is to approach multimedia cautiously. Do not commit to doing a whole course right off the bat. Try your hand at a presentation or two, at most. Then evaluate what you have done. Try, if possible, to experience the presentation as the students would, sitting in their seats, using the computer facilities that they use, and so on. Talk to your colleagues who have some experience. Above all, keep your expectations realistic.

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