Chapter 9
Teaching with Technological Tools

David A. Cook

The first use of educational technology probably occurred when someone picked up a stick and drew in the sand, or when someone picked up a piece of cinder and wrote on a cave wall. Chalk, papyrus, paintings, printed books, chalkboards, and more recently photographs, overhead projectors, televisions, and computers all represent technological advances that can used for educational purposes. It is common to become fascinated – or infatuated – with new technologies, but it is important to remember that these technologies are simply tools to support learning. No technology, no matter how sophisticated, will supplant a skilled teacher, effective instructional methods and designs, or – most importantly – the central role of the student in the learning process.

In recent years, computers have found an increasing role in medical education. Not only has computer-assisted learning (CAL) taken off, computers are now used to support face-to-face learning through the use of PowerPoint™, audience response systems, and multimedia (graphics, animation, sound and video). This chapter will emphasize such technologies, not because they are more important than or superior to older technologies, but simply because they are new and educators must become comfortable using them. However, teachers should consider all of the technologies available and use those methods that best serve the needs of the learner. The use of simulation is covered in another chapter in this book.

Fundamental Principles

Before discussing any specific technologies it is worth reviewing a few fundamental principles about how people learn, and also some principles about the effective design of multimedia presentations. These principles will be relevant to all of the educational technologies subsequently discussed, and are summarized in Tables 9.1 and 9.2.

D.A. Cook (✉)
Mayo Clinic College of Medicine, Rochester, MN, USA
e-mail: cook.david33@mayo.edu

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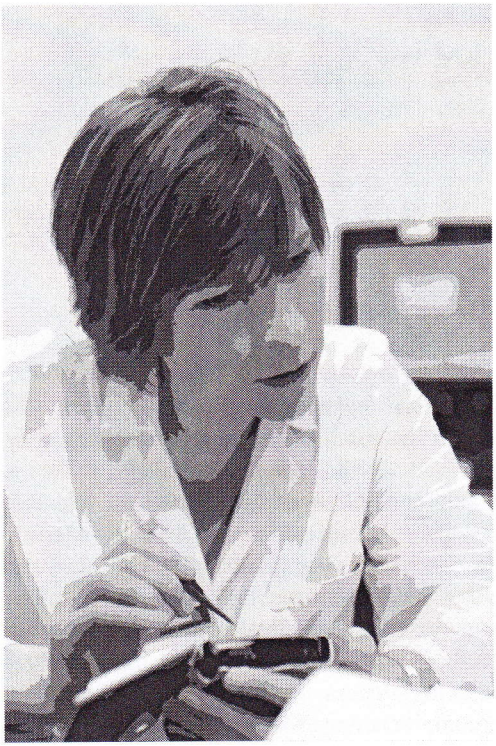


Core Principles of Instructional Design

As in all instruction, the use of educational technology should focus on helping learners effectively construct new knowledge rather than trying to effectively transmit information. Learning is more than accumulation of information, but rather involves organizing, reorganizing, and linking new information and experiences with prior knowledge and past experience. This process, known as elaboration, constitutes the core of all learning. Educational technologies will be most effective inasmuch as they encourage learners to construct robust, meaningful knowledge structures.

In considering how to accomplish this, Merrill (2002) reviewed the literature looking for common themes among various educational theories and models, and distilled five "first principles of instructional design." First and foremost, all instruction should be situated in the context of real life *problems*. This is not synonymous with problem-based learning per se, but rather implies that patient cases (or other relevant problems) should figure centrally in all instruction. The second principle is *activation* – "learning is promoted when relevant previous experience is activated." Activation means that prior knowledge (including formal instruction and

lived experiences) is brought to the forefront of working memory, where it can be integrated with new experiences and information. The third principle is *demonstration* – "learning is promoted when the instruction demonstrates what is to be learned, rather than merely telling information about what is to be learned." Next comes *application* – "learning is promoted when learners are required to use new knowledge or skills to solve problems." Guidance and coaching should be provided initially, and then gradually be withdrawn such that in the end learners can solve problems independently. Finally, *integration* – "learning is promoted when learners are encouraged to integrate (transfer) the new knowledge or skill into their everyday lives."

Designing Effective Multimedia

Based on decades of empiric research, Mayer (see Clark and Mayer, 2007) has formulated several principles of effective multimedia learning (Table 9.1). These principles are relevant to computer-assisted instruction, PowerPoint™ presentations, and other uses of audio and video in instruction.

Multimedia Principle: People Learn More from Graphics and Words than from Words Alone

A picture is worth a thousand words, and it comes as no surprise that graphics, photographs, animations, and short video clips can greatly enhance learning. Graphics help learners construct effective mental representations. While irrelevant graphics actually detract from learning (see below), relevant graphics can be used to illustrate examples (and non-examples) of an object, to provide a topic overview or organization scheme, to demonstrate steps in a procedure or process, or to illuminate complex relationships among content, concepts, or time or space.

Modality Principle: When There Are Graphics, Present Words as Speech Rather than Onscreen Text

New information can reach working memory through separate visual and auditory pathways. Learning is maximized when both pathways are optimally used. For example, a graphic accompanied by spoken explanation (both pathways used) will be more effective than the same graphic accompanied by onscreen text (vision-only). Paradoxically, when identical information reaches working memory simultaneously via both vision and hearing (such as when a presenter reads their PowerPoint™ slides verbatim) it can actually impair, rather then enhance, learning. Thus, the modality principle encourages teachers to maximize mental capacities by using both visual and phonetic information, while avoiding redundancy (presenting identical text onscreen and as speech).

Contiguity Principle: Related Information Should Be Placed Close Together

It is common to include an explanatory legend at the bottom of a figure. However, this physical separation of information wastes mental energy that could be better spent on learning. It is far more effective to place the explanatory text within the figure itself. This helps learners appreciate relationships (=build meaningful knowledge), and it minimizes the cognitive effort spent going back and forth between a figure and the accompanying text. The same principle applies to non-graphical elements, such as putting the directions for an exercise on the same page as the exercise itself, or presenting the question and the answer/feedback together when providing formative feedback on an online test.

Coherence Principle: Avoid the Extraneous (Less Is More)

Interesting but irrelevant details detract from learning. This includes sounds, graphics, or unnecessary words. Teachers often add cartoons or photos to presentations for aesthetic value (to "spice up" a lecture), but such decorative graphics can actually impede learning rather than enhance it. The same applies to extraneous sounds, interesting but irrelevant stories, unnecessarily detailed descriptions, and most animations. Not only does extraneous information tax cognitive capacities, it can also ***distract*** the learner from more relevant material, ***disrupt*** the learner from building appropriate mental links, and ***seduce*** learning by activating inappropriate prior knowledge which leads to flawed knowledge structures. The purpose of words, graphics, and multimedia in instruction is to help learners construct mental representations. If they do not serve this purpose, they should probably be removed. As John Dewey once stated, "When things have to be made interesting it is because interest itself is wanting. The thing, the object is no more interesting than it was before." (Dewey, 1913, p. 11–12) Bottom line: if it doesn't facilitate learning, leave it out.

Guided Discovery Principle, Worked Example Principle, and Expertise Reversal Effect

Many educators have advocated unstructured learning environments, claiming that freeing learners from the tethers of rigid instruction will enhance learning. However, abundant research suggests that this is not the case – at least, not all the time. The guided discovery principle states that learning is enhanced when information is presented in a planned sequence and when learners are assisted in their interpretation of this information – in short, when learners are guided in the learning process. This guidance need not be excessive. In fact, too much guidance diminishes the need for learners to think deeply about new information and weakens the resultant knowledge structures. The worked example principle is similar, namely that learning is enhanced when some practice problems are replaced with worked examples.

However, as learners advance they require progressively less guidance and become increasingly independent in solving problems. This transition from supported to independent learning and problem solving has been labeled the **expertise**

Table 9.1 Principles of effective multimedia learning

Principle	Learning is enhanced when ...
Multimedia principle	Both words and graphics (pictorial information) are used
Modality principle and redundancy principle	Descriptions of graphics are spoken rather than appearing as on-screen text, but concurrent written and spoken text are avoided
Contiguity principle	Related information (graphics and accompanying explanation; instructions; feedback) is placed close together (on the same page, and close together on page)
Coherence principle	Only necessary information (graphics, words, sound) is presented
Personalization principle	A conversational tone is used
Learner pacing principle	Learners can control the pace of the course
Guided discovery principle	Structure (content selection, sequencing, and interpretation) is present for novice learners
Worked example principle	Some (but not all) practice problems are replaced with worked examples
Expertise-reversal effect	Structure and worked examples are provided for novice learners, while advanced learners receive less structure and unsolved problems

See Clark and Mayer (2007) for details and additional principles of multimedia learning.

reversal effect. What works for novices will not work for more advanced learners, and what works for advanced learners won't work for novices. Learners should initially be provided guidance and worked examples, and progress to independence.

Educational Technologies as "Mindtools"

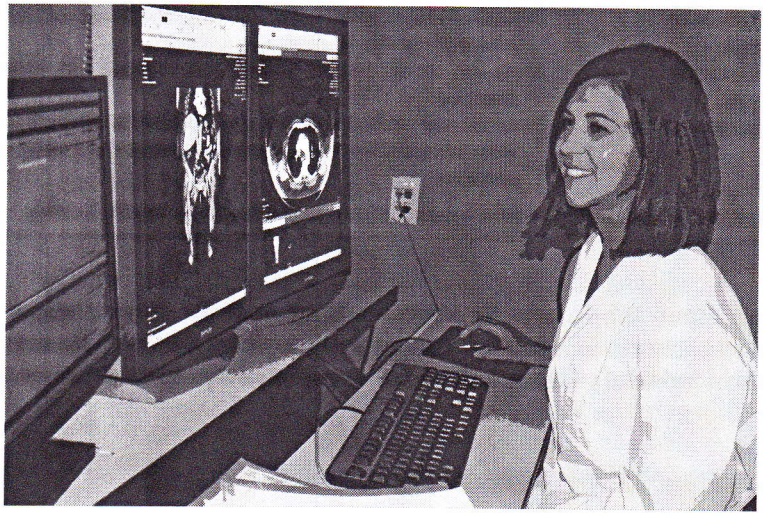
Jonassen (2000) has suggested that students should learn *with* computers rather than *from* computers. By this he means that instead of sitting in front of a computer tutorial, students should use computer-based tools such as word processing, spreadsheet, and database programs; programs to generate semantic maps; and online discussion as "Mindtools" to facilitate knowledge elaboration. Other educators have assigned learners to produce PowerPoint™ presentations, web pages, or video clips related to the topic of study. This paradigm – using computers and other technologies as knowledge organization tools, rather than tools for the transmission of knowledge – merits consideration and further research.

Faculty Training

A critical, but often overlooked, issue in the use of educational technologies is faculty training. Training needs include the technical and instructional skills (they are different!) required to develop an effective educational object such as a CAL

Table 9.2 General tips when using educational technologies

- Consider the need for educational technology: Are simpler technologies or traditional instructional methods adequate? Is this the *best* technology to meet the needs of this group/content/context?
- Spend less time/energy/money on bells and whistles, and more time planning for effective learner interaction
- Consider how you will stimulate active learning
  - Structure learning around a problem (e.g., patient case)
  - Activate prior knowledge, demonstrate, allow opportunity for application and integration
- Follow principles of effective multimedia learning
- Provide time for learning; set deadlines
- Practice or pilot the course before implementation



module, PowerPoint™ presentation, or video clip, and the skills to integrate these objects effectively into a course. This chapter provides an introduction for faculty that focuses on the instructional aspects.

Computer-Assisted Learning

We will now discuss a number of specific educational technologies, beginning with CAL. CAL in all forms requires a paradigm shift for the teacher. Direct interaction with the learner is greatly reduced or eliminated altogether. However, the teacher continues to interact indirectly by virtue of the course/website design and the instructional methods selected.

There is nothing magical about CAL that makes it inherently better than other forms of instruction (such as face-to-face lectures or small groups). Decades of research have failed to detect any consistent advantage once changes in the instructional design/method are accounted for. Hence, educators should not jump to CAL as a solution for all instructional problems. Indeed, in many situations it is likely

an inferior choice. Traditional methods or blended learning – using various combinations of CAL and traditional methods – are often the most effective approach. CAL comes in many flavors or configurations, including tutorials, online communities, virtual patients, performance support, online resources, and portfolios. Each of these will be discussed in turn.

Computer-Based Tutorials

What It Is

Computer-based tutorials are similar to face-to-face lectures. They consist of structured information, often enhanced by multimedia and interactivity. Such tutorials are often Web-based, although they can also be implemented on specific computers or using digital media.

When To Use

Computer-based (and in particular Web-based) tutorials have advantages such as flexibility in the physical location or timing of participation; the presentation of a consistent and easily updated message; learner self-pacing; facilitation of assessment and documentation; and a number of novel instructional methods that are difficult to implement in other modalities. However, there are also a number of disadvantages, including difficulty in adapting to individual needs; social isolation; development and maintenance costs; and technical problems. Computer-based tutorials will be most useful when learners are separated in time or space (such as conflicting schedules or rotations at different sites).

How To Use

When planning a CAL tutorial, it is important to do your homework. The initial development costs are likely to be great (perhaps much more than you anticipate), and this and other disadvantages should be balanced against potential advantages. Be sure that you have adequate technical support at your institution. Consider who will be doing the programming and who will provide technical support when problems arise. If commercial software meeting your needs is available, it may be cheaper to purchase this rather than develop a new program in-house. Proprietary learning management systems such as Blackboard or free, open-source systems such as Moodle can be helpful in organizing your course.

When developing the course itself, pay attention to the design principles noted above. In particular, remember that the goal of instruction is mental activity on the part of the learner – elaboration of information and construction of new knowledge. Physical activity (such as clicking the mouse) does not guarantee mental activity; direct your design to facilitate mental activity. Opportunities for self assessment and feedback, reflection, and interaction with other learners can facilitate this. Also, well designed interactive components can help. However, keep in mind the coherence principle – if it does not add to learning leave it out. Clark and Mayer (2007) provide additional considerations in thorough detail.

Also pay close attention to the website design. In addition to Mayer's principles, Web pages should be organized for consistency and clarity. Use the same basic layout from one page to the next within your course. Create a visual hierarchy to focus attention, and chunk related information together. Make it clear at all times, "What can I do on this screen, and where do I need to go next?"

Before implementation, pilot the website in terms of both functionality and appearance. Make the website readily accessible to learners. Secure commitment from all stakeholders – not just from the administration, but also from faculty and learners. Don't forget to provide time for learning. There is temptation to tack a Web-based course onto an already full schedule. CAL permits flexible scheduling, but does not prolong the hours of the day. Table 9.3 summarizes these recommendations.

Table 9.3 Tips for computer-based tutorials

- Use commercial software if it meets your needs
- Get buy-in from administration, faculty, and students
- Distinguish physical and mental activity: clicking mouse $\neq$ learning; try to stimulate mental activity
- Make site accessible and user-friendly

Online Communities: blogs, wikis, and discussion boards

What It Is

Internet-mediated communication has facilitated the development of so-called online learning communities. In the virtual equivalent of a face-to-face small group discussion, learners can interact to share experiences and information and learn collaboratively. As with face-to-face small groups, online learner interaction serves both a social function and as a stimulus to active learning.

Most online communication is asynchronous – there is typically a delay between sending a message and receiving the response. Tools for asynchronous communication include e-mail, threaded discussion boards, blogs, and wikis. Synchronous communication is real-time, and is mediated through Internet chat rooms and instant messaging. In a threaded discussion, a learner or facilitator makes an initial post on a specific topic to pose a task or a question for comment. Responses are grouped according to the message to which they are responding. One message might have five responses, and each of these responses could in turn have any number of responses. The discussion thus spread like paths diverging in a forest, yet the collective train of thought for any given path can be easily followed as one picks up one end of the "thread" and follows the conversation to the end. Blogs (short for web logs) consist of dated posts organized in reverse chronological order. There is no threading or branching, and often only one person (the author) contributes to the posts. Usually there is a provision for visitors to comment on the content of the blog. Wikis, from the Hawaiian word for quick, allow all users to contribute to revisions of the same document or web page.

When To Use

The advantages and disadvantages of online communities compared to face-to-face small groups are similar to those described above for tutorials. They will be most useful when learners are unable to meet together face-to-face (in fact, it is probably preferable for learners to meet in person when possible).

One might choose threaded discussion when the emphasis is organization of communication around specific themes or topics; blogs when the goal is documentation of personal impressions, such as e-portfolios (discussed in greater detail later on) or a journal; and wikis when the objective is a collaboratively developed final product.

How To Use

After deciding to develop an online learning community and selecting the appropriate configuration, the next step is to identify or train a qualified facilitator. Effective online small-group facilitation requires a unique skill set. The "e-moderator" must ask questions, challenge points of view, provide summaries and synthesis, redirect when a discussion goes astray, promote active participation from all group members, and encourage a healthy social environment. At the same time, the facilitator must remain a "guide on the side" and ensure that the learning evolves from group collaboration.

Online learning communities seem to work best when some degree of structure is provided. The facilitator will typically pose a question or specific task to the members of the group. For example, a problem-based learning task might give a group an unstructured case and ask members to analyze the case (see Chapter 4), identify problems, and come up with a solution. Case analysis is similar but emphasizes the identification of root causes of the problem rather than solutions, often considering multiple different paradigms or perspectives. Critical incident discussions ask students to identify a formative experience (such as an influential positive role model, or an error made in patient care) and identify salient details of this incident. Groups then identify common themes among their experiences.

It is often helpful to assign students to work in groups of two to five to ensure that everyone has an opportunity to participate. There are various permutations on this theme, such as breaking apart and reorganizing groups halfway through an assignment, encouraging participants to work as individuals initially and then collaborate for the final product, or begin as a group and then submit a final product written alone. Wikis allow groups to work collaboratively on a single final product. Firm deadlines should be fixed well in advance (on or before the first day of the course, if possible). Interim deadlines are useful as well.

It is often appropriate for the facilitator to post resources such as journal articles and book chapters (provided copyright law is taken into account), written introductions or summaries, slide presentations, or links to external websites. However, these should not supplant the collaborative group learning process.

Two serious threats to online communities are inflammatory communications between group members and silence. The first problem ("flaming") can lead to a loss of mutual trust and disintegration of the collaborative environment. Those involved in heated discussions should be redirected by the facilitator, and if this proves unsuccessful they may need to be excluded from participation. "Lurkers" read messages but do not post responses. Not only are such individuals less likely to learn deeply, but by failing to contribute they negatively affect the experience for all. After detecting lurking, facilitators should first try encouraging participation from all participants generally. If this is unsuccessful they may need to resort to one-on-one communication with the individual student.

Learners should be taught the rules of "netiquette" that govern online communication. First and foremost be polite. Learners should carefully proofread messages before posting and consider whether their words could be misinterpreted. Typos can be confusing, and small errors in spelling and punctuation can completely change the meaning of a sentence or paragraph. Writing in ALL CAPS is considered yelling and should be avoided. Empty messages such as "I agree" should be shunned in favor of more informative comments about *why* the individual agreed. Participants should carefully read what has been previously posted to avoid repeating comments. Humor should be employed with great caution: without voice inflection and physical gestures it is easy for messages to be misinterpreted. Finally, participate: all communication in the community should be done in a common forum (such as the discussion thread), except when personal feedback to an individual might be inappropriate for a group setting (such as from the facilitator to someone who is flaming or lurking). Table 9.4 summarizes tips for online communities.

Table 9.4 Tips for developing online learning communities

- Choose a configuration appropriate to learning goals: email, threaded discussion, blog, wiki
- Train the facilitator
- Assign tasks that promote meaningful collaboration and learning
- Develop the social aspects of the group
- Beware of lurkers and flaming
- Judiciously incorporate online resources such as websites, documents, multimedia, and slide presentations
- Teach "netiquette": participate, be polite (proofread messages, review for alternate interpretations, no personal attacks), avoid all capital letters, no empty messages

Virtual Patients

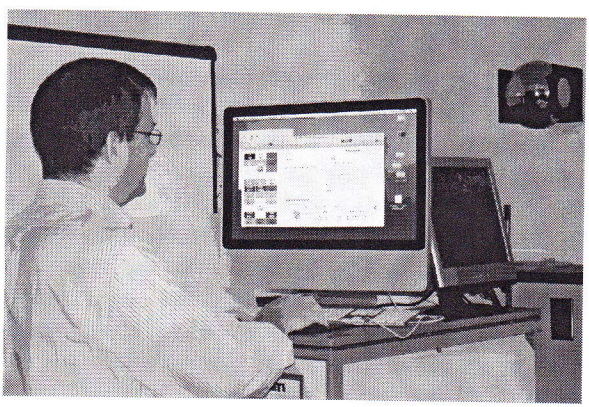
What It Is

A virtual patient is "a specific type of computer-based program that simulates real-life clinical scenarios; learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions" (AAMC Report, 2007). The defining feature (and limitation) is the attempt to mimic reality on a computer screen. Virtual patients can range from patient cases that

develop linearly with occasional prompts for the learner to make decisions or request additional information, to complex simulations that branch in response to learner questions and actions.

When To Use

The evidence base regarding virtual patients is limited, and most recommendations are based either on extrapolation from other forms of CAL or on conjecture and expert opinion. The most appropriate role of virtual patients appears to be the development of clinical reasoning. Lectures and CAL tutorials are probably superior for the development of core knowledge, and standardized patients or real patients are superior for the development of history taking, examination, and counseling skills. However, a growing body of evidence suggests that there are no generic problem solving skills in medicine (or any other subject), but rather that problem solving skills (such as diagnostic reasoning or selection among management options – collectively termed clinical reasoning) involve a large amount of pattern recognition. Hence, the development of clinical reasoning requires a large number of patterns, which derives from seeing lots of patients. If real-life experience is insufficient, supplementing the mental case library with simulated experiences may help. Virtual patients provide an efficient way to provide such experiences.



How To Use

The key consideration in teaching with virtual patients involves the selection, sequencing, and implementation of cases. Ideally, cases on a given topic would start off relatively simple (and perhaps with some guidance in decision-making) and progress to more challenging cases with greater complexity and less guidance. Looking to facilitate elaboration (which George Bordage [1994] has termed "the key to successful diagnostic thinking"), teachers might encourage learners to explicitly contrast two or more cases, to justify the elements of history, exam, and laboratory

testing they select, to rank diagnoses in the order of probability, to explain how their choices might change with a slight variation in the clinical scenario, or to identify the evidence in favor of their management strategy. Feedback might consist of an expert's approach to the same case, an index of concordance with accepted guidelines, or measures of cost or time efficiency.

Regarding the design and implementation of virtual patients, technological sophistication does not equate with better learning. Much attention is paid to the fidelity or realism of the virtual patient. However, these concerns are likely ill-founded. Not only is high fidelity expensive, but there is some evidence to suggest that it can paradoxically impede rather than enhance learning. Likewise, while intuition suggests that asking learners to type questions into the computer to elicit a history may be most effective, evidence suggests that selecting questions from a preset list of standard questions may be more effective. Finally, many virtual patients require learners to click on specific body organs to examine them. It is unclear whether this activity enhances learning (mental activity) or merely represents physical interactivity.

The development of a good virtual patient library can be difficult. Not only are scenario scripts time-consuming to prepare, but the technology to turn a script into a working virtual patient can be expensive. Efforts such as the MedBiquitous virtual patient standards group and the AAMC's MedEdPortal are working to facilitate the sharing of such resources among institutions. Authoring tools such as CASUS and WebSP can help, and commercial products such as DxR Clinician should also be considered.

Even after cases have been developed, there is still the issue of how to integrate these into a curriculum. Some educators have found that working through a virtual case as a group is more effective than working alone, or that virtual patients are most effective as part of a blended learning activity (for example, having a face-to-face group discussion once everyone has completed the case). Additional considerations include: Will cases be mandatory or optional? What is the right balance between virtual patients and real patients? Are learners who have seen real patients with a similar problem able to opt out? How will learners find time to work on cases? What training will teachers need in the use of the software and specific cases, and how will institutional buy-in be achieved?

Just-In-Time Learning (Performance Support)

What It Is

Just-in-time learning involves delivering educational information at critical stages in a clinical encounter (performance support). Information can be "pushed" to the provider (such as automated feedback in response to specific triggers in computerized order entry, feedback linked with electronic prescribing patterns, or CAL packages that tailor their activity and response to individual practice patterns) or "pulled" by the provider (online searchable resources, personal digital assistants [PDAs], or smart systems that provide quick access to needed information). The

essence is that the learner (who is often a practicing healthcare professional) can either seek, or be automatically provided with, information relevant to the patient sitting in front of them. The theoretical educational advantages are at least twofold. First, this is a moment when learners (practitioners) will be receptive to the material, since it (hopefully) will enable them to provide improved patient care. Second, because a knowledge gap has been identified and prior knowledge activated, learners are primed to integrate this new information into their existing knowledge structure.

When To Use

Just-in-time learning is used when learners (providers) are seeing patients. As useful as this sounds, it has limitations. It takes time to read, digest, and assimilate this information in a busy clinical schedule, and learners may resent mandatory pop-ups or unsolicited e-mail reminders if these affect their practice efficiency. Also, just-in-time learning may not substitute for other instructional approaches because the ad hoc, unstructured information may be improperly integrated. For example, a teaching point relevant to one patient may be over-generalized to a population for whom a different rule should apply; or the knowledge structure may be left with gaps not addressed by the performance support system. Thus, performance support – at least at present – is just that: support. It should not replace (at least not completely) other instructional methods.

How To Use

The paucity of evidence makes specific recommendations difficult; however the suggestions for CAL tutorials likely apply. Additional questions to consider include how much information to present, how to organize and structure this information to facilitate meaningful learning, how to motivate learning, and what will trigger the information to appear? Effective instructional methods (which usually take more time) must be balanced against the time constraints of a busy clinical practice. As evidence and experience accumulate performance support systems will likely become more prevalent in coming years.

Online resources such as Google™ and UpToDate have become the first line information source for many practitioners. However, the availability of such resources does not guarantee that they will be used, or used effectively. The same pedagogical concerns described for "pushed" information apply here. Furthermore, online resources raise the danger of unguided discovery – which, as noted above, can be detrimental for novice learners. The presence of misinformation on the Internet is another potential danger.

Portfolios and Online Assessment Tools

What It Is

An important part of teaching is learner assessment, and computers can facilitate this in numerous ways. The administration of online self-assessment and summative

tests is now commonplace, and typically allow automated grading and immediate personalized feedback.

Education portfolios can include a variety of information and "artifacts" relevant to a student's professional development, similar to an artist's portfolio of completed works. Relevant information might include case reports, patient logs, records (written, audiotaped, or videotaped) of performance, essays, research project reports, and self-reflection narratives. Online tools can simplify such portfolios. Logbooks are a specific type of portfolio used to keep track of procedures performed and patients seen.

When To Use

Online self-assessments are useful as pretests, interim tests, or posttests to help learners identify strengths and knowledge gaps. Formative feedback can itself be a powerful instructional method. Online summative assessments can be used for grading and documentation in addition to providing feedback.

Portfolios are particularly helpful in assessing domains that do not lend themselves to multiple-choice tests, such as attitudes, critical thinking, application of theory to practice, and progress over time. Since students study what will be tested, portfolios provide one way for teachers to emphasize these important elements of training. Reflection itself is an important instructional method that can be facilitated by portfolios. Portfolios will likely see greater use as the limitations of existing assessment tools are increasingly recognized.

How To Use

Specific information on assessing student performance can be found in Chapter 11. Many commercial and open-source tools are available to facilitate online testing.

When considering an online portfolio, the first decision is what type of information you wish students to include. These materials should align with the objectives of the course or curriculum. Students will need clear guidelines about the type of materials to be included and the narrative or explanation to accompany each component. Deadlines are important. Clear grading criteria, aligned with the objectives of the course, will need to be established and shared with the student. Such criteria might assess the organization of materials; the amount of thought and reflection evidenced in discussion; and other criteria specific to the type of material included (such as scores on a multiple choice test, or scientific rigor in a report on a research activity). Faculty development may be needed for both the faculty members who assist the students in developing the portfolio, and also those who assign grades.

Software for the development of online portfolios could be as simple as a blog or a wiki, or the student's personal page in a learning management system, or a software package designed for this purpose. Personal digital assistants (PDAs) are now used for many portfolio purposes, including patient tracking and procedural logbooks.

PowerPoint

What It Is

For many decades, 35 mm slides were the primary presentation-support tool. Today, slides have been largely replaced by the use of PowerPoint™. In the 20 years since its first release this software has developed into a powerful and versatile presentation-support tool. Software (e.g., Camtasia™ and Articulate™) is also available to turn PowerPoint™ presentations into polished Web-based learning modules. Specially designed screens (Smartboard™) can seamlessly integrate whiteboard techniques (the traditional "chalk talk") with a PowerPoint™ presentation.

When To Use

Although PowerPoint™ presentations are ubiquitous today, they are often not necessary. In fact, for many teaching purposes an open discussion or use of a chalkboard or whiteboard may be more effective. PowerPoint™ will be most useful for formal presentations, such as scientific reports, or when multimedia (particularly graphics and photographs) will enhance the teaching session. However, PowerPoint™ is a tool – and as with all technological tools, can be overused.

How To Use

Developing a PowerPoint™ presentation can be fun because of all the things you can do. However, first and foremost you should focus your time and energy on developing the content and organization of the presentation rather than the PowerPoint™ slides. Think more about how to mentally engage the audience and less about how to execute PowerPoint™ animations and transitions.

The principles described above for effective multimedia learning apply to PowerPoint™ as much as they do to CAL. In particular, the coherence principle applies to the use of PowerPoint™ slides. Most notably, slides should be simple. Use no more than five to seven words per line, and no more than five to seven lines per slide. This may not seem like a lot (and you've likely seen this principle violated frequently) but slides should list merely the key points. You, the teacher, will then elaborate on these points – but if you put full sentences or excessive information, the audience will begin to read your slides (a violation of the redundancy principle). If you must add a direct quote, put only a short excerpt on the slide.

Consistency is a virtue. Using the same fonts, font size, color scheme, and transitions, and even similar clip art styles, will enhance learning by minimizing distraction. The slide master (View → Master → Slide master) allows you to control default settings for the entire slide show. Never use a font smaller than 28-point. Avoid nonstandard fonts (fancy fonts are both harder to read and also may

not be available on a different computer). Colors should contrast, but avoid garish combinations such as green on red. Dark text on light backgrounds is easiest to read. In addition, a light background lends itself to writing on the slide using a SmartBoard™. Each slide design (more below) comes with a palette of colors for text, title, accents, hyperlinks, etc.; try to stick with this palette rather than using other arbitrary colors. Finally, just because PowerPoint™ offers lots of options for fancy transitions and animations does not mean you need to use them. In fact, simpler slide shows – with "boring" standard transitions – are usually more effective. PowerPoint™ allows the use of multimedia including clipart, photographs, charts and diagrams, tables, sound, video, and hyperlinks to Internet sites. All of these are useful when used appropriately, but as with everything else can be overdone. Use them only when they truly enhance the presentation.

Presentations often take longer than you think; plan at least 1 min per slide, and time your presentation before presenting. Instead of reading slides verbatim, put only the key points on your slides and then elaborate on these as you talk. Face the audience (not your slides) when presenting. If you are using a video clip be sure to try it out on the computer system you will be using – you may find the clip does not run on a different computer or project well using a different projector.

Although detailed instructions on using PowerPoint™ are beyond the scope of this chapter, there are a few features that you may find useful. *Slide designs* allow you to choose from a variety of templates with background, colors, and fonts that have been selected (hopefully) because they work well together. As noted above, the *slide master* can help with consistency within the presentation. The *slide layout* feature has several standard text layouts, including a title slide, text slides, text and graphics, etc. *Custom animation* can be used to introduce certain elements of a slide in sequence (for example, if you don't want all of the text or graphics to be visible at once) but it should not be overused. Finally, the *speaker notes* (typing text below the slide that is not visible to the audience) can be invaluable both for organizing your thoughts, and also for when you come back to give the presentation again at a later date. Table 9.5 summarizes these and other tips.

Table 9.5 Tips for using PowerPoint

- Spend more time on the content and organization than on designing your slides
- Plan for interaction with the audience
- Follow the Coherence Principle:
  - Just the essentials on slides (you'll fill in details verbally)
  - Simplicity and consistency (use slide master and color scheme)
  - Bullet points: 5–7 words per line, 7 lines per slide
  - Large, simple fonts (no less than 28-point font)
  - Colors: contrasting and vibrant but not garish
  - Minimize transitions, animations, sound, and other effects
  - Use clip art, pictures, sound, video, tables, and hyperlinks to support learning (not decoration)
- When presenting
  - If using video: test in advance on presentation computer
  - Practice and get feedback; time your presentation
  - Don't read slides, and don't read *to* slides

Audience Response Systems

What It Is

Audience response systems (ARS) actively engage the audience in the lecture. Commercially available ARS provide each attendee a small keypad with which they respond to questions posed by the lecturer. Responses are relayed via infrared or radio frequencies to a computer that integrates responses and displays them immediately in a PowerPoint™ presentation. Another approach requires each attendee to have a laptop computer linked (typically via wireless) to a central network through which they can work collaboratively and interactively on a variety of projects. This latter approach requires greater infrastructure but also provides greater flexibility.

When To Use

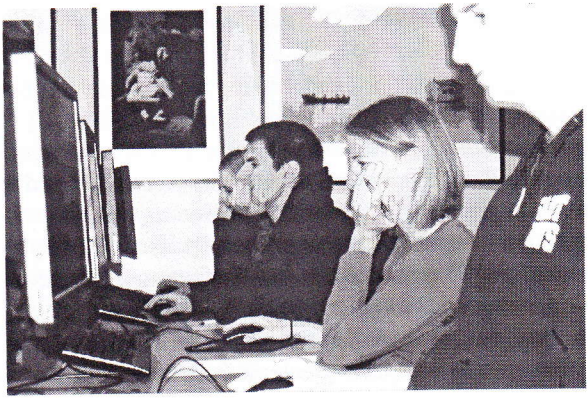
ARS will be most useful when teaching a large audience; for smaller audiences verbal interactions might be more appropriate. An effective, interactive non-PowerPoint™ lecture probably need *not* be altered just to use a PowerPoint™-enabled ARS. Audiences may become complacent with ARS if they are overused.

How To Use

Complex questions will confuse the audience and derail the lecture. Thus, ARS questions should be short, simple, clearly written, and typically employ five or fewer response options. Questions should be used sparingly in the presentation – predominately to emphasize key points. Since the whole purpose is to encourage audience interaction, questions should be designed to stimulate discussion and time should be budgeted to permit such discussion. Transitions (introducing the question, presenting responses, initiating discussion, and then resuming the lecture) should be rehearsed. When lecturing in a new venue the ARS should be tested well in advance to ensure that everything works properly. If the audience is unfamiliar with the ARS, you will need to provide clear instruction on how to use the keypad. When teaching the same learners over time (e.g., a medical school course) consider assigning keypads and tracking individual responses. Table 9.6 summarizes these recommendations.

Table 9.6 Tips for using audience response systems

- Keep questions short and simple, and use ≤ 5 response options
- Use questions to emphasize key points and stimulate discussion
- Allow time for (and encourage) discussion of answers
- Rehearse, preferably in proposed location
- Provide clear instructions to audience
- Do not overuse



Similar principles will apply when using a more complex system (e.g., wireless network). Do not let fascination with the capabilities of technology take precedence over effective instructional design.

Video

What It Is

Video recordings for instructional purposes can range from brief clips integrated into lectures to full length feature films. Videoconferencing can allow a teacher at one location to reach an audience at another. Video archives or podcasts of lectures are increasingly commonplace. This section will deal primarily with the first of these uses, namely the use of video as an instructional technique.

When To Use

Video can be judiciously used to enhance any teaching activity. It can "reveal" the remote (separated by barriers of distance), the invisible (such as microscopic events or abstract concepts), and the inaccessible (unavailable due to risk or infeasibility). However, when experiences (such as lab experiments, patients, and procedures) are visible and accessible it makes sense to encounter them in person. Copyright issues should be considered before using video produced by others.

How To Use

First and foremost it is important to define the purpose for using the video. Video can be used to provide an overview or stimulate interest at the beginning of a course; to demonstrate principles, concepts, skills, procedures, or positive or negative role

models; or as a "trigger" to self-assessment and critical reflection. Your purpose will define the type of clip, the length, and most importantly the way in which you use the material. A teacher may occasionally wish to show a full-length film, but more often short clips – preferably less than 5 min in length – will be more appropriate.

If learners are not encouraged to think before, during, and after the video the exercise will become a passive process (=ineffective learning). Careful planning will prevent this problem. Before starting the video, you should describe the context: the plot (especially if showing an excerpt from a longer film), the characters, and the setting. It is usually appropriate to provide an overview of what viewers will see and what they might learn, although in some instances this information might be withheld. It is always important to provide a specific objective and/or task to focus learners' attention. For example, you might suggest they watch for specific events; attend to dialogue, body language, or emotions; identify underlying assumptions, principles, or paradigms; or reflect on their own reactions and perspectives. Consider pausing the video midway to recap what has happened or ask learners to predict ensuing events, or try turning down the sound and narrating events. Discussion following the video should be encouraged.

Rather than using pre-existing video, learners might be video recorded during a role play with another student, an interaction with a standardized patient, or a procedure. This video can then be reviewed one-on-one or (cautiously, and with permission) as a group as a stimulus for self assessment, reflection, and formative feedback.

Recent developments in digital video have brought relatively sophisticated editing techniques within the purview of many educators. While a detailed discussion of specifics of videography is beyond the scope of this chapter, one useful online reference is provided at the end of this chapter. Table 9.7 summarizes these recommendations.

Table 9.7 Tips for using video

- Have a clear purpose – why are you using this clip?
  - Reveal remote, invisible, or inaccessible
  - Activate prior knowledge
  - Demonstrate principle/concept/skill/procedure
  - Trigger for discussion, self-assessment, reflection, attitude change
- Set the context (plot, characters, situation); consider providing an overview
- Focus attention: define objective (what can be learned) and/or task in advance
- Keep clips focused (typically <5 min)
- Encourage learners to think
- Pause to recap, discuss, predict next events
- Don't infringe copyright

Other Educational Technologies and Conclusions

This chapter could not begin to address all of the technologies available to educators today. Technologies such as overhead projectors, 35 mm slides, whiteboards and black boards, and printed materials are probably familiar to educators. Newer

technologies include virtual microscopy, virtual cadaver dissection, and simulations of various kinds. Teachers are also using clinical technologies to enhance their teaching; for example, some medical schools perform whole body CT scans of cadavers prior to anatomy lab dissection.

Given these technologies and others not mentioned, educators are faced with an ever-growing toolbox from which to select specific instructional approaches. It is easy to become enamored with one or more technologies and forget the big picture. Educational technologies are only tools to help learners learn more effectively. Those who wield these tools should not only be skilled in their use, but must know when to use each one and when a different tool is needed.

References

Bordage G (1994) Elaborated knowledge: A key to successful diagnostic thinking. Acad Med 69: 883–885.

Clark RC, Mayer RE (2007) E-learning and the science of instruction, 2nd edn. Pfeiffer, San Francisco, CA.

Dewey J (1913) Interest and effort in education. Boston: Houghton Mifflin Co.

Jonassen DH (2000) Computers as mindtools for schools: Engaging critical thinking, 2nd edn. Merrill Prentice Hall, Upper Saddle River, NJ.

Merrill MD (2002) First principles of instruction. Educational Technology Research and Development 50(3): 43–59.

Summary Report of the 2006 AAMC Colloquium on Educational Technology (2007) Effective use of educational technology in medical education. Association of American Medical Colleges. Washington, DC, https://services.aamc.org/publications

For Further Reading

General principles

Clark RC, Mayer RE (2007) E-learning and the science of instruction, 2nd edn. Pfeiffer. San Francisco

Merrill MD (2002) First principles of instruction. Educational Technology Research and Development 50(3):43–59

Summary Report of the 2006 AAMC Colloquium on Educational Technology (2007) Effective use of educational technology in medical education. Association of American Medical Colleges. Washington, DC https://services.aamc.org/publications

Curriculum Repositories

Med EdPORTAL "http://www.aamc.org/mededportal" www.aamc.org/mededportal

Health Education Assets Library (HEAL) HYPERLINK "http://www.healcentral.org" www.healcentral.org

Merlot "http://www.merlot.org" www.merlot.org

Computer-assisted learning

Cook DA, Dupras DM (2004) A practical guide to developing effective web-based learning. J Gen Intern Med 19:698–707

Ellaway R, Masters K (2008) AMEE Guide 32: e-Learning in medical education Part 1: Learning, teaching and assessment. Med Teach 30:455–73; Part 2: Technology, management and design. Med Teach 30:474–89.

Ruiz JG, Cook DA, Levinson AJ. (2009) Computer animations in medical education: a critical literature review. Med Educ 43:838–46.

Online communities

Sandars J (2006) Twelve tips for effective online discussions in continuing medical education. Med Teach 28:591–3

Sandars J (2006) Twelve tips for using blogs and wikis in medical education. Med Teach 28:680–2

Virtual patients

Cook DA, Triola MM. Virtual patients: A critical literature review and proposed next steps. Med Educ 2009; 43:303–11.

Huwendiek S, Reichert F, Bosse HM, et al. (2009) Design principles for virtual patients: a focus group study among students. Med Educ 43:580–8.

Portfolios

Driessen E, van Tartwijk J, van der Vleuten C, Wass V (2007) Portfolios in medical education: why do they meet with mixed success? A systematic review. Med Educ 41:1224–33.

PowerPoint

Holzl J (1997) Twelve tips for effective powerpoint presentations for the technologically challenged. Med Teach 19:175–9

Audience response systems

Robertson LJ (2000) Twelve tips for using computerised interactive audience response system. Med Teach 22:237–9

Video

Mitchell K Videography for educators. Available via http://edcommunity.apple.com/ali/story.php?itemID=365. Cited 9 October 2007