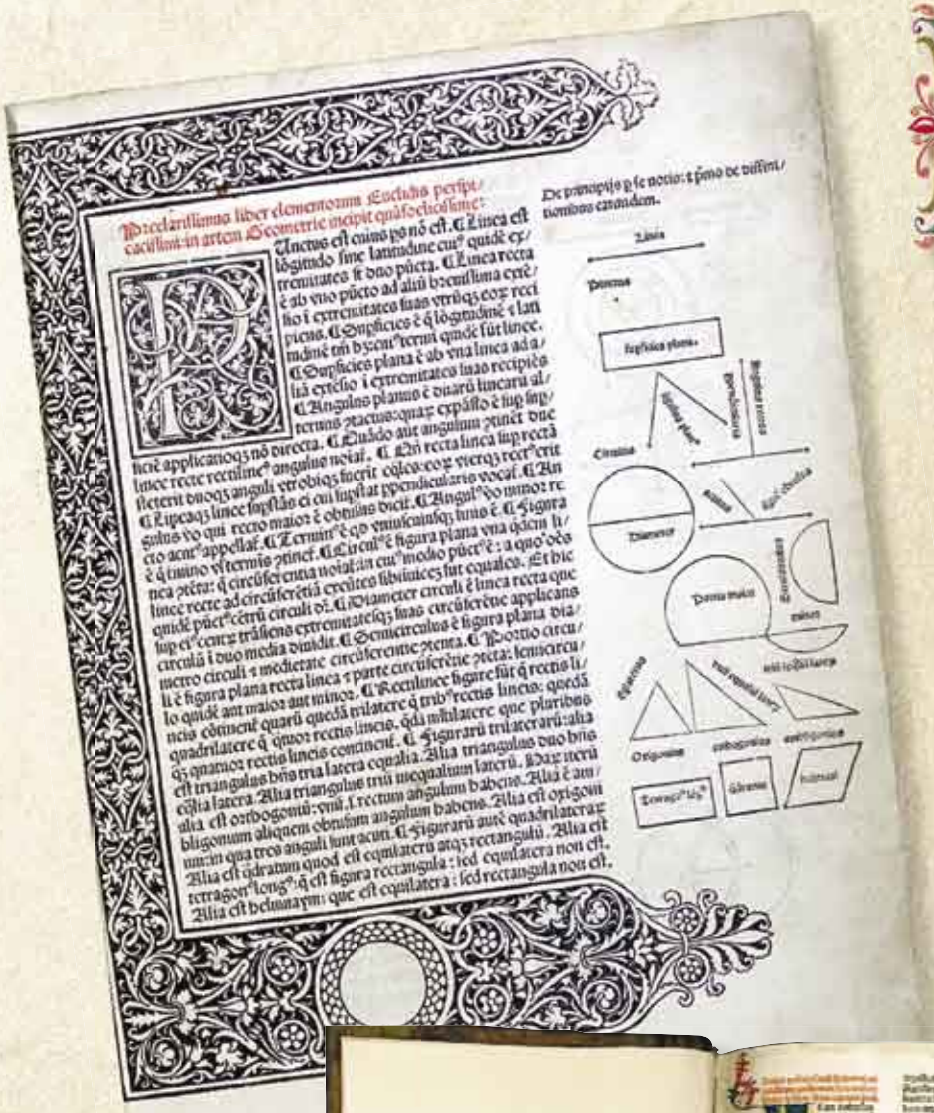
EMERGING FROM THE CRADLE

By Glen Bull, Joe Garofalo, and Randy Bell

Subject: Using new technology effectively

Technology: Projection systems, tablet PCs, wireless access

Standards: *NETS•T* II; *NETS•A* II (http://www.iste.org/standards/)

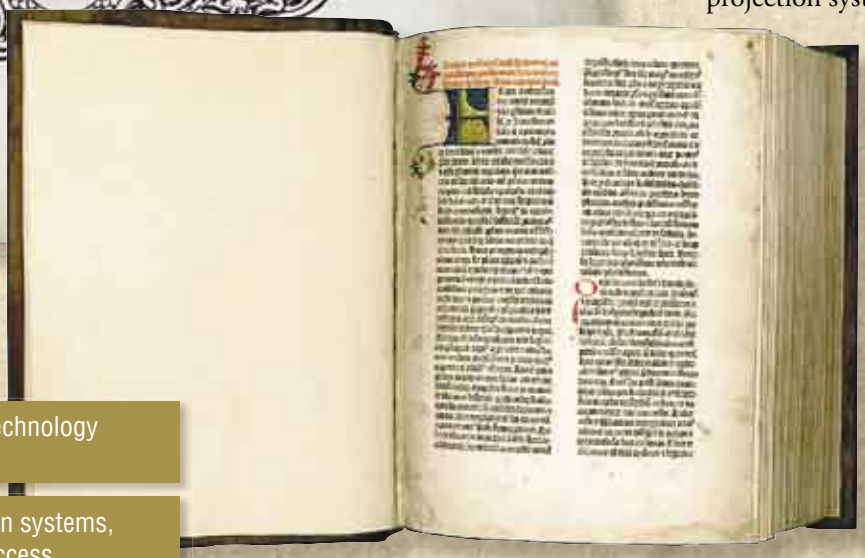


Page from Euclid's *Elementa Geometriae* printed in 1482.

New technologies often assume the form of prior traditions during their infancy. For example, filmed plays known as photoplays were initially produced prior to the development of modern cinema conventions. Similarly, printed books at first assumed many of the characteristics of hand-lettered manuscripts.

The term *incunabula* is used to describe books printed during this transitional period. It is the Latin term for cradle. The infancy of books lasted for the first half century after the invention of the printing press. It took a half century to discover the utility of inventions such as page numbers, the table of contents, and indexes. Even the typography initially mimicked that of hand-penned illuminated letters that, although ornamental, are much less readable than the modern typefaces of today.

We are still in the cradle period of computing technologies in the classroom. Consider, for example, projection systems. The decreasing price of computer projectors means that they will soon enter classrooms in large numbers. Under proper circumstances, a classroom projector can facilitate visualization and whole-class inquiry. However, the way a projector is used is critical.



Gutenberg Bible printed in 1455.

The predominant model of use in the corporate world, universities, and administrative meetings in schools currently consists of static slide show presentations. This model employs the pro-

jector in much the same manner as a blackboard or overhead projector. Bulleted items are listed on slide after slide. This is typical even at technology conferences. It is not surprising that this static use echoes the prior technologies, because that is often the case for emerging technologies in the incunabula period.

Prerequisites for Effective Use of Projectors

Many teachers have only seen projection systems used by their instructors for static presentation of lecture notes. Consequently, they follow this model in their own teaching. To realize the full potential, however, teachers must go beyond these static models. Projectors used correctly can effectively deliver the potential of the Internet and computer technology to an entire classroom. Teachers can display evocative digital images, demonstrate mathematical modeling software, and lead whole-class explorations of scientific phenomena. One of the most important uses of a computer and projector is its capacity to display change over time, thus, providing a three-dimensional picture of events that would be difficult to understand otherwise.

Because the idea of using a projector for more than a slide show of lecture notes is new to many teachers, it is important to begin considering the instructional capabilities that go beyond substituting the computer projector for a chalkboard or overhead projector.

Effective use of a projection system to support student inquiry in a whole-class setting requires deep knowledge of content-specific tools and software, an associated understanding of related concepts in the content area, and pedagogical knowledge of how computer projectors can best be used to facilitate inquiry. The requirements for effective use can be characterized as an instructional trinity of content knowledge, content-specific software, and pedagogical knowledge incorporating both.

Preparing teachers to use projectors effectively for instruction in this manner is a non-trivial task. These uses differ by subject, so it is necessary to consider applications in each content area. For example, in the mathematics education program in the Curry School of Education at the University of Virginia, preservice mathematics teachers learn to use content-specific tools with projectors in mathematics methods classes over the course of two semesters. These tools include The Geometer's Sketchpad, electronic spreadsheets, and graphing tools. Specific ways to facilitate inquiry, visualization, and understanding are discussed in the context of the content to be taught. These students use their knowledge of content, software, applications, and pedagogy to design effective instruction for the single-computer classroom.

Similarly, future science teachers learn to use subject-specific tools such as interactive simulations to teach abstract scientific concepts such as the Doppler effect, digital microscopes in biology, digital cameras that can be connected to telescopes in astronomy, and applications for visualization and understanding of vectors in physics. Future science teachers learn how these kinds of content-specific tools can be used to increase student engagement in learning through interactive visualization.

Need for School Leadership

Many administrators do not realize the amount of preparation required for effective use of projectors for whole-class instruction. They conceive that the prerequisite skills involve knowledge of the location of the power button on the projector and of the location of the "Advance Slide" option in the slide show program.

Author Edward Tufte argues that use of projectors solely for electronic slide shows can adversely affect the children's cognition, concluding that, "Students would be better off if the schools simply closed down" on the days slide shows are presented.

The decreasing cost of projectors will soon allow them to enter classrooms in large numbers. Hence, this is an opportune time to develop models for effective use. The most crucial variable is the pedagogical perspective. Models for student engagement that provide scaffolding for active inquiry are preferable to those that consist solely of didactic presentations of static slides. As the foregoing suggests, content knowledge and content-specific tools play an important role. Classroom infrastructure also is a significant variable.

Wireless Technologies

Keyboard and Mouse. Many potential models of interactivity incorporate shared use by the teacher and the students. One method for achieving interactivity is simply to allow a student to walk over to the classroom computer, in the same fashion as the student previously might have walked to the blackboard.

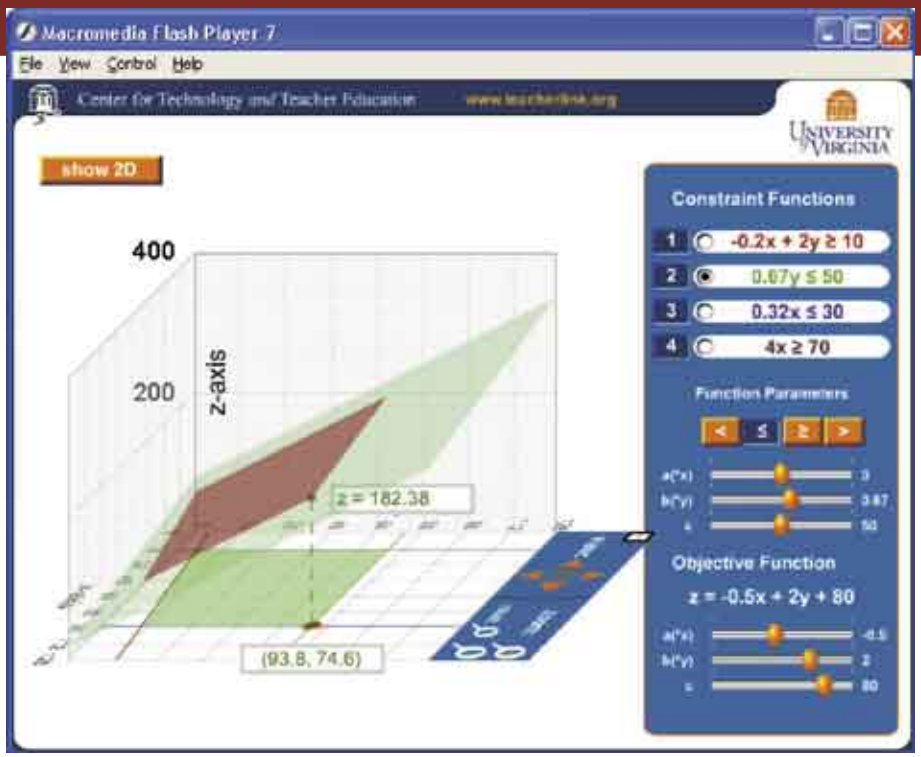
Wireless technologies now offer a number of other options that can facilitate even greater interactivity. A wireless keyboard and mouse can be placed at any point in the classroom, untethering the teacher from the desktop computer. Equally important, a wireless keyboard facilitates a greater degree of interaction and participation by students, because it can be passed from student to student around the classroom.

Two types of wireless keyboards are available. Infrared connections require a direct line of sight between the keyboard and the computer. This type is better suited to office use than to classroom use. A second type of wireless keyboard relies on a radio frequency (RF) connection. A direct line of sight is not required, and the keyboard can be passed freely around the classroom. A wireless keyboard of this kind can be purchased for $100 to $200.

The Tablet PC. Another possibility for interactive classroom use of projectors has potential. A new generation of pen-enabled computers known as tablet PCs is now available. The operating system for a tablet PC supports use of a magnetic pen that can be used to write on a touch-sensitive screen. The tablet PC offers new capabilities potentially well suited to classroom instruction.

A tablet PC in slate format allows a math teacher to use a stylus for manipulating software, such as The Geometer's Sketchpad. Similarly, in English class, the teacher and students can use the stylus to annotate compositions and literature. Several emerging applications in science and mathematics make effective use of the tablet's pen interface. For example, one application under development provides the teacher with an interactive writing surface on which mathematical equations can be written just as they might be on a blackboard. However, the pen-based mathematics tool automatically generates results and graphs associated with the equations.

The static two-dimensional spaces in mathematics textbooks and on blackboards are not ideal spaces in which to represent some topics in secondary mathematics. Teachers sometimes resort to presentation of these subjects in rote fashion. We have developed tools to dynamically transform a two-dimensional graph into a three-dimensional graph containing all components of the task (http://www.teacherlink.org/content/math/). In our work, dynamic three-dimensional representations have been effective in helping teachers and students develop a conceptual understanding that underlies these mathematical methods. A projection system is essential for use of these tools with a class.



Interactive display of a linear mathematics problem in a three-dimensional space.

The University of Virginia is currently engaged in a program to pilot use of several hundred tablet PCs in the College of Arts and Sciences. A pen-based interface can potentially facilitate teaching in a variety of ways. For example, biochemistry professor Charles Grisham will use tablet PCs to interact with three-dimensional models of proteins in his classes.

Tablet PCs are available in two form factors. A convertible tablet PC has an attached keyboard that can be rotated to fold out of the way when it is not needed. The slate format is the second type of tablet PC. A slate has a detachable keyboard that connects through a USB cable or through a wireless Bluetooth connection. The slate format is particularly well suited for classroom use when the keyboard is removed because it can be easily passed from student to student.

To obtain maximum flexibility for a tablet PC, it is necessary to untether it from the projector. This can be accomplished in a couple of ways. A new generation of wireless projectors is emerging. These allow a tablet PC (or any PC for that matter) to be connected to the projector through a wireless connection. The technology for wireless projectors is still evolving, but ultimately will provide the greatest degree of flexibility for the classroom. At the time this is being written, one manufacturer has announced a projector suitable for classroom use retailing for $1,000 that can be upgraded to wireless capability for an additional $200.

The initial generation of wireless connections was implemented with a standard known as 802.11b, which provides a maximum capacity of 11

A slate-format tablet PC.

A convertible tablet PC with an attached rotating keyboard.

megabits per second. A subsequent standard now widely available is 802.11g, which provides a fivefold increase in capacity. This capacity is potentially fast enough to support streaming video applications, a desirable feature for classroom use.

Wireless Links to Existing Projectors

The technology for wireless projectors is still evolving, and many schools already have some existing projection systems that lack this capability. However, there are other ways to link an existing projector to a tablet PC through a wireless connection. Most classrooms already have one desktop computer. The existing desktop PC can be connected directly to the projector with a hardwired cable.

Once the link between the desktop computer and projector is in place, the tablet PC can be linked to the desktop PC through a wireless connection. A number of programs allow one computer to control another remotely through a wireless connection. One of the more popular programs of this kind that has been available for some time is the Virtual Network Computing (VNC) application.

VNC software makes it possible to view and fully interact with one computer from any other computer or mobile device anywhere on the Internet. This cross-platform program originated as open source software that is available to schools without charge. One of the more popular versions of VNC can be obtained at http://www.realvnc.com. Because a tablet PC used in this mode is wireless, the teacher is untethered and can use proximity as a classroom management method and even hand the tablet to individual students to allow them to respond to a question interactively.

Models and materials are needed to prepare teachers for a shift in instruction made possible by these new capabilities. We are currently exploring use of Tablet PCs and projectors by science and mathematics teachers to identify how their use may best facilitate interactive whole-class inquiry.

Conclusions

Recently, the cost of computer projectors has fallen dramatically. Consequently, many schools are beginning to buy projectors in increasing numbers. However, many teachers are not prepared to use this technology effectively to enhance instruction. Research into effective models of use will be needed to take advantage of the potential of new capabilities.

It is particularly important for school leaders to realize that explicit preparation will be needed to introduce new models of interactive use of projection systems. Without thoughtful preparation, teachers are likely to use these new capabilities in ways that offer little benefit over previous modes of instruction. On the other hand, these new technologies offer the potential for well-prepared teachers to provide greater opportunities for student engagement and inquiry-based instruction through unprecedented access to educational technology in the single-computer classroom. These steps are needed to move out of the cradle period and capitalize on the potential for enhanced learning.

Glen Bull is co-director (with Joe Garofalo) of the Center for Technology and Teacher Education in the Curry School of Education at the University of Virginia.

Joe Garofalo is co-director (with Glen Bull) of the Center for Technology and Teacher Education in the Curry School of Education at the University of Virginia.

Randy Bell is an assistant professor of science education in the Curry School of Education at the University of Virginia.