Chapter Six

Computer-Assisted Instruction (CAI)

It is the supreme art of the teacher to awaken joy in creative expression and knowledge.

Albert Einstein (1879-1955)

If a student flunks once, he is out; but an inventor is almost always failing—he tries and fails maybe a thousand times. ... Our biggest job is to teach how to fail intelligently... to keep on trying, and failing, and trying.

Charles Franklin Kettering (1876-1958)

LEARNING OUTCOMES

The term Computer-Assisted Instruction (CAI) describes digital systems that are designed to assist in the learning process, specifically those that can be tailored to the needs of the individual student. When originally defined, CAI described systems comprised of discrete hardware and software, tailored to different teaching methodologies and focused upon a curriculum core (reading, language arts, math). Current use of this term embraces a range of instructional solutions, from courseware applications to district-wide, web-based integrated learning systems.

In general, educational use of technology has migrated from "technology tutoring" to the concept of "technology tools," as discussed in chapter 5. However, as also discussed in chapter 5, NCLB has reinforced the need for standards-based education, resulting in a general re-thinking of the role of CAI in schools[1]. In this chapter we will examine the various types of CAI with a view to broadening your awareness of what is available in the way of computer-based tools to support education and your understanding about how to use them effectively.

It is beyond the scope of this book to profile in more than cursory fashion specific CAI applications. We are concerned here with concepts, rather than keystrokes. The ideal accompaniment to the study of the material in this chapter, and in the book as a whole, would be hands-on review of as wide a range as possible of CAI applications and tools.

Courseware—software designed to promote specific learning goals—such as age-specific reading, writing, mathematics, science, social studies, music and arts skills—is abundant and available at a price[2]. Increasingly, courseware is being developed by individuals and

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[1] Private schools may not be guided by NCLB. This decision depends upon funding needs and school philosophy.

[2] Educational pricing, group purchasing plans and state-supported purchasing plans mean that schools pay much less for computer software than does the public. So it should always be purchased through the school. This is also a wise move in terms of appropriate use licensing.

smaller development teams and made available as *freeware* or low cost *shareware*[3]. Increasingly, teacher-created materials are available over the Internet. Teachers are planning lessons around these tools. We will explore some specific uses of sample tools, for finding the best tool for the task is an important part of the planning process (and a lesson that students will learn by doing!). Teachers are also learning to implement the standards-based CAI that are often available school or district-wide. There are advantages to both computer integration solutions and it is the teacher's role to guide students in their use on a day-to-day basis. General strategies for the successful integration of technology will be explored in Chapter 14. Teachers are also using a third category of CAI, perhaps the one that will be first to the finish line in upcoming years—web-based learning content. We will touch upon it here and cover it in some depth in chapter 9.

This chapter also will examine the process of courseware and software evaluation since, although there are many examples of well-designed courseware, teachers should still evaluate learning materials prior to incorporating them into lessons plans. They must also evaluate the effectiveness of those materials *while* students are using them, and again *after* their use in order to determine whether or not they should be used again. This evaluation should be shared with other teachers. Computer technology can help with this task in various ways.

The following topics will therefore be dealt with in this chapter.

- Children want to learn
- Technology Tools: Students and productivity software
    - Productivity Software is a Platform for CAI
    - Word Processing
    - Database Tools
    - Spreadsheets and Charting tools
    - Drawing and Painting—Graphics Tools
    - Authoring or Presentation Software
    - Graphical Organizers
    - Communications
- Technology Teachers, Tutors & Testers: Classifications of CAI
    - Caveat: The teacher should come bundled with the software
    - Software for Drill-and-practice
    - Software for Tutorials
    - Software for Simulations and Gaming
    - Software for Critical Thinking
    - Software for Supporting Learning
    - Computer-based Laboratories (CBLs)
    - Programming and Problem-solving
    - Integrated Learning Systems
- Software evaluation

[3] Freeware is distributed freely, but often with little support. Shareware requests a registration be paid to the developer. Both are generally distributed on the Internet.

- The design of effective software evaluation instruments
- The process of CAI system evaluation and purchase
- The Future

INTRODUCTION

The French writer and educator Anatole France once wrote: "Let our teaching be full of ideas. Hitherto it has been stuffed only with facts... The whole art of teaching is only the art of awakening the natural curiosity of young minds for the purpose of satisfying it afterwards." Learning *is* more likely to take place if natural curiosity is awakened. As any teacher knows, children to some degree at least can be coerced into the kind of academic achievement that is measured by scores on standardized tests. But knowledge acquired out of inherent interest in the subject matter is much more likely to persist and be retained than that acquired purely for the purpose of passing tests. Inherent interest in the subject matter of a discipline also provides a surer foundation for life-long learning.

Children Want To Learn

A Nation at Risk (The National Commission on Excellence in Education, 1984) recognized "the natural abilities of the young that cry out to be developed and the undiminished concern of parents for the well-being of their children." The report's recommendations "are based on the belief that everyone can learn, that everyone is born with an *urge* to learn which can be nurtured, that solid high school education is within the reach of virtually all, and that life-long learning will equip people with the skills required for new careers and for citizenship."

The teacher's task is to nurture the student's innate "*urge* to learn." In this chapter we will look at the various ways in which computer assisted instruction (CAI) can be one tool, but by no means the only tool, for accomplishing this objective.

TECHNOLOGY TOOLS: STUDENTS AND PRODUCTIVITY SOFTWARE

Ralph Waldo Emerson observed: "The person who can make the hard things easy is the educator." Before we examine categories of CAI, we will take a look at how the same productivity tools discussed in chapter 5 can be used by students. The term *productivity* is used to describe these applications, which are the workhorses of any organization, because workers can get more done in less time when the computer is used to assist them. The same applies to students, who undertake every day the essential job of learning. There is no reason why these applications should not also be the workhorses for the students in a computerized classroom. Creating the opportunities and presenting the possibilities is the teacher's role. At the end of this chapter, teachers should understand this axiom: a minimum of software used well is more powerful than a maximum of software used poorly.

Productivity Software Is a Platform For CAI

Productivity software provides study tools for all aspects of learning. Chapter 1 showed how learning in the language arts, math, science and social studies can be enhanced by incorporating computers into the curriculum. All areas of study require the acquisition of data, or information, in response to curiosity and inquiry. Productivity software empowers the student to *make something* of this information.

The computer has become one of the most important tools to support research, regardless of the academic discipline or level. Students, guided by good teachers, use databases, spreadsheets and graphical organizers to capture, manipulate, and organize data. They use word processors to write about the data. They use graphics tools to design materials to accompany their written and/or spoken descriptions of what they have learned. They use presentation or authoring software to produce multimedia presentations to share their learning.

This process of capturing, manipulating, organizing, and presenting is a profound learning experience, especially when facilitated by a teacher who knows how to stimulate inquiry, who understands when to leave students alone to discover knowledge by themselves, and who is ready to step in with ideas and guidance of an enriching nature that will redirect and reinvigorate flagging research or inquiry

Educator Jamie McKenzie (1999) writes often about the power of Questioning in the research process. A good exercise for the teacher is the examination of his research cycle model (http://questioning.org/Q6/research.html), with an eye toward understanding how and where productivity software can support the cycle. Gathering, synthesizing, sifting and sorting, revising, and publication are all facilitated by the right productivity tools. This applies to the kindergartner examining letters or bugs, to the AP chemistry student examining recumbent DNA, and to everything in between. When combined with the use of technology to present, access or communicate information, productivity tools become powerful tools for learning.

It is beyond our scope here to dwell more than superficially on the technical aspects of productivity software. Readers should note, however, the sets of tutorials which optionally accompany this text. These tutorials introduce the user to the essential features of the Microsoft Office software, using examples that are appropriate for the classroom. [4]

These tutorials are available for free download online at the following URLs:

Essential Microsoft Office 2000: Tutorials for Teachers
http://www.pitt.edu/~edindex/Officeindex.html

Essential Microsoft Office XP: Tutorials for Teachers
http://www.pitt.edu/~edindex/OfficeindexXP.html

[4] Tutorials for Office X for the Mac are available from Microsoft at the following URL: http://www.microsoft.com/Education/MacOfficeTutorial.mspx .

Essential Microsoft Office 2003: Tutorials for Teachers
http://www.pitt.edu/~edindex/Office2003frame.html

Essential Microsoft Office 2007: Tutorials for Teachers
http://www.educationworld.com/a_tech/columnists/poole/office_tutorials/index.shtml

Let us briefly examine, from the students' point of view, the features of each of the components of productivity software.

Word Processing

In an information age, an individual's ability to communicate effectively both orally and in writing is a key ingredient of success, even of economic survival. An important goal of education, therefore, is to help students develop good communication skills. Teachers are role models, whether they like it or not. Their students look to them for example and direction. So, teachers as well as students should constantly work on improving their speaking and writing skills.

A good place to start might be to take more advantage of the word processor, which is the most used of all computer applications. Chapter 1 made the case for the word processor as a tool for learning. It is already revolutionizing the teaching of writing in computer-integrated elementary and secondary classrooms. A recent study in Maine, which has a 1-1 laptop program for grades 7 and 8, concludes that the more students use their laptops for writing, the better their writing scores are (Silvernail 2007).

Children prefer writing at a computer because of the ease of text modification and revision, and because of the improved appearance of the final product. The net result of this is that the children are motivated to write more, and this alone leads to improved writing skills, especially when they are working with teachers who provide a "prepared environment" where spontaneous intellectual growth can flourish. Not only are the children more likely to become better writers using a word processor; they also are more likely to blossom in all areas of academic life.

Myers (1984) makes a powerful case for Writing to Learn Across the Curriculum. "Writing to learn," he writes, "is based on a growing body of research into the writing process that suggests that writing can be a powerful strategy for learning content. The student who participates in a writing to learn program is likely to learn more content, understand it better, and retain it longer. As a bonus, writing skills are also likely to improve through use." Myers goes on to say: "Writing should be an integral part of any instructional program. It is unfortunate that, outside the English classroom, most teachers provide only limited writing opportunities for their students, usually in the form of note-taking or an occasional essay question on an exam. Writing can do much more. Properly used, *it can become the single most powerful tool a teacher can employ*." (Emphasis added)

There are many teachers who routinely expect their students to use the word processor for writing, no matter what the academic discipline involved. They routinely work with their students to revise word processed writing assignments until they are of an acceptable standard. Such revision is a natural, almost inevitable, component of writing when assignments are word processed. Unlike hand- or type-written work, when the word processor is used revision is much more likely to occur *before* the assignment is handed in. In fact, Microsoft *Word* facilitates comment and revision by making a powerful set of editing tools available to the teacher and student (see Fig. 6.1).

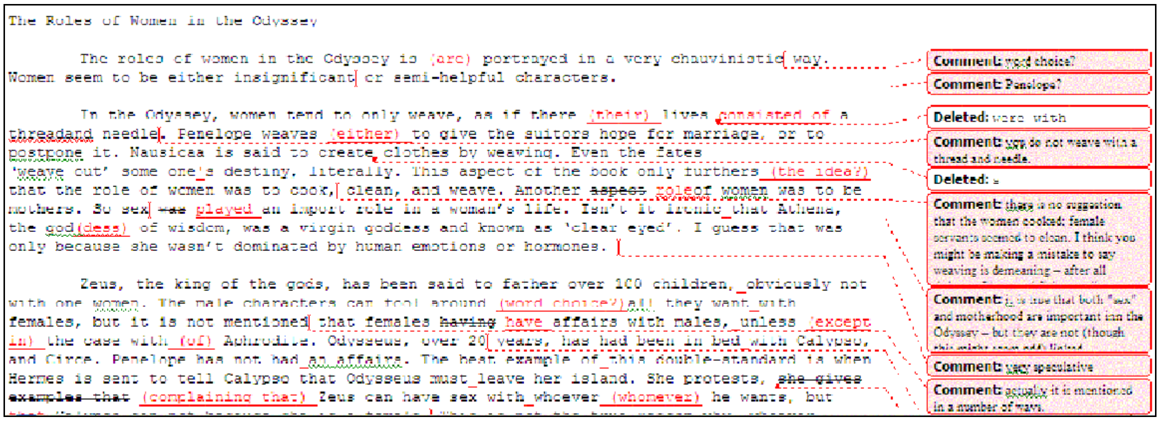

Fig. 6.1 Editing tools put to use in *Word XP*

Many teachers are encouraging peer editing and collaboration on the computer, as early as grade 1[5]. Because the basic word processing tools for formatting and layout are consistent across platforms and software applications, students develop strong skills as they move through the k-12 experience.

Did you know…
The word processor is the best tool for collecting notes for online research. URL's can be dragged directly into *Word*, *Pages* or a note-taking application, where they will become hyperlinks! Even better, images can also be inserted by drag-and-drop!

If we use computers for no other purpose than to actively promote writing across the curriculum, we will have already taken a huge step towards improving the overall quality of children's educational experience. If we also have the students using those word processing skills to communicate over local and wide area computer networks, as discussed in chapters 7 through 9, we can foster the kind of collaborative writing in, and between, students and subject area experts in more and more schools.

Keyboarding remains a conundrum. In general, research indicates that students write more and better if they can keyboard faster than they can write by hand. It is not the role of the classroom teacher, however, to teach keyboarding. Many solutions are available: computer labs often undertake structured keyboarding lessons using proven software such as *Type to Learn* and *Mavis Beacon Teaches Typing*. Some schools enlist the help of parents to oversee keyboarding practice at home. Other schools have invested in inexpensive, portable keyboarding/word processing tools, such as the *Neo* and the *Dana*

[5] Although *Word* and *Pages* are accessible to early elementary school students, application such as Davidson's *KidWorks*, Crick's *Clicker*, and *Kidspiration* have features that make them good alternatives.

(http://www.renlearn.com/neo/). Whatever the keyboarding solution, every school that encourages or expects word processing should have a CAI solution, and the teachers should be aware of it.

Database Management

A database program is designed to help the user create files containing up to hundreds or thousands of records, capture the data, store it, rearrange it, sort it on specific fields, select subsets of records and of fields within records, and produce reports. Although modern databases are designed to carry out mathematical operations on numbers, this is not their primary function for student use. For the most part the database is best at handling plain text, numbers and words, dates, and, increasingly, images and multimedia objects.

Idea Bank: Databases
Summer reading books
Class facts
Historical events/people
Pets
Mammals
Biomes
Favorite movies, TV shows…
Immigration/immigrant groups
What grows where
States/Country facts
Fitness testing results
Our trips
Polygons

Fig. 6.2 illustrates a typical database data entry form for the Microsoft Office *Access* database management system.

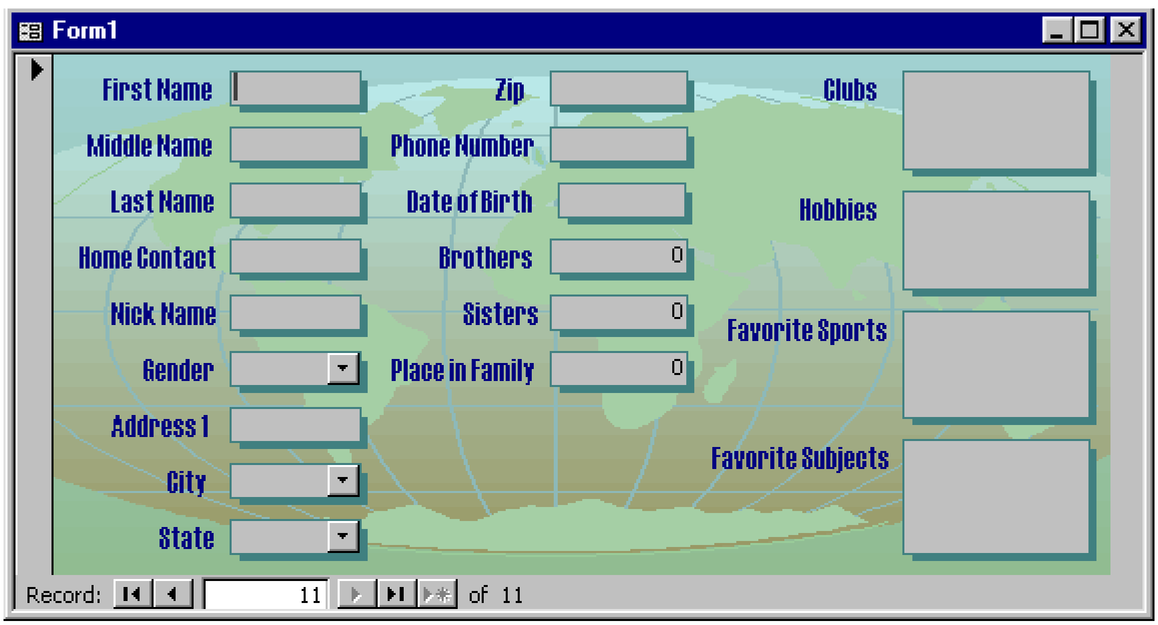

Fig. 6.2 *Access* database data entry form

The database component of productivity software is relatively easy to use once you have mastered the concept of database management. This means practice. It also means learning to design a database activity that is appropriate to the age group and curriculum. As is the case with software in general, less is often more. Students can be introduced to databases by entering data into teacher-designed forms. Children of all ages can do this, perhaps as early as second grade. Even at the kindergarten and first grade levels, the teacher may be able to hand over most of the data entry to the students.[6]

Teachers should remember that when students access a web Browser, like Google, they are searching a database! But just because students *google*, they might not google well! Searching well is NOT intuitive – it must be taught. Accurate keyword searching is an essential element of using the Internet for CAI.

In teaching students how to use databases, teachers are also modeling how to *make* databases. For older students, teachers can design long term team projects in which students research a subject, design a database to capture the data, assemble the data, produce reports using the database package and the word processor, and make a presentation based on their findings. Teachers can locate online projects that extend the data set around the globe—or even design and manage their own!

> **Did you know…**
> Most Internet forms now send data to or collect data from a searchable database. As early as kindergarten, students are familiar with these forms and eager to use them. But the COPPA (Children's Online Privacy Protection Act) makes it unlawful for websites to solicit information from children under 13 without parent approval. Teachers must teach children Internet safety rules and guide them toward "kidsafe" search engines, such as KidsClick! (http://sunsite.berkeley.edu/KidsClick!/)

Working with a database can be an important exercise in higher order thinking. For example, databases can require students to classify data by selecting from a checklist of descriptors or categories. Searching a database by dates or keywords can yield "found lists" from which students can create conclusions by compare-contrast, cause-effect, inference, locating patterns or predicting outcomes. Returning to Jamie McKenzie, the database structure invites good criteria for information collection and facilitates the "filter and revise" steps so critical to good research methodology. Asking *questions* of a database develops another essential skill for the digital age; students using a well-designed tool will learn that information is a powerful thing—almost too easily accessed and manipulated.

A new addition to database productivity tools is the *visual mapping of data*. Increasingly, data that is input via an online form can be viewed visually rather than in a table or "record." Not surprisingly, students are fascinated by these tools. Teachers wishing to learn more might peruse a favorite blog for a *tag cloud* (Fig 6.3 next page) or try out a "next generation" visual search engine such as *KartOO* (http://www.kartoo.com).

[6] It is a fact of life today that most students have entered information into online databases by age 10.

Fig 6.3 Tag cloud

Spreadsheets and Charting Tools

A spreadsheet, like a database, is a powerful tool for gathering and storing data, manipulating it and presenting it in various ways. The difference is that a spreadsheet is primarily designed to handle numeric data, whereas a database is best for handling discrete snips of information media. A spreadsheet file consists of a grid of rows and columns. At the intersections of rows and columns are cells into which the data are entered. Fig. 6.4 illustrates a typical spreadsheet exercise using the Microsoft Office *Excel* spreadsheet software.

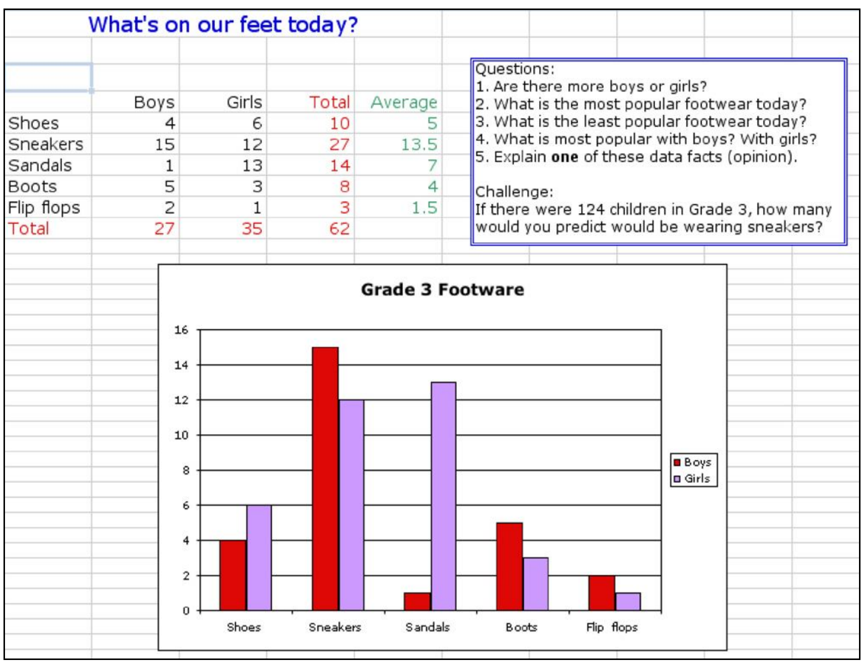

Fig. 6.4 A spreadsheet is made up of cells divided up into rows and columns

This example uses a *text object* to provide questions; answers could be entered into a second text object. It also displays a *bar graph* of the data, facilitating comparison of boy-girl totals by providing a visual display. In the classroom, a word-processed survey form could be used to tally footwear data as it is collected.

It would be a good teaching strategy to have all students complete a sample spreadsheet, like this one, and then allow students to work in teams to design and complete a survey of their own. There are many extensions of an activity begun in this way: writing, math, interviews, research, explorations of how data sets interrelate (for example, if there has been a survey of favorite free time activities, students could ask if more boys like sports because they wear the most sneakers).

Idea Bank: Spreadsheets

Surveys of anything that can be counted
How I will spend $100
A cross-country travel plan
Keeping track of homework time
Class fund-raising project
Ocean depth, mountain height
How many of what color? (Skittles, M&M's, Froot Loops, buttons)
Plotting numerical progressions and patterns—squaring, cubing, halving, incrementing
Environmental studies data
Grammar counts—count occurrences of "which" or ";"
Probability and prediction
Calories and nutrition journal

The strengths of spreadsheets are their functions and their graphing and charting capabilities. *Functions* are mathematical formulas (such as *total all the values in such and such a column*) that direct the spreadsheet to carry out mathematical or logical processing. Such processing, done manually, would be time-consuming and error prone if done by hand, even with the aid of a calculator. Many of the spreadsheet functions are built-in, such as the *sum* and *average* functions, used in the spreadsheet shown in Fig. 6.4. But users can also create their own formulas by expressing in mathematical terms the functions they want calculated. Additionally, some of the more difficult concepts, such as *mean* and *median*, can be reinforced when data is viewed on a spreadsheet.

All spreadsheets today have a variety of graphing and charting tools. The user can specify a set of values in the spreadsheet—say all the values in a sequence of cells—and press a few keys to tell the spreadsheet to draw a pie chart, bar chart, line chart, or a combination of chart types, including 3-dimensional charts. The chart can then be inserted, as an information clip, into a word-processed document, a presentation or poster, and so forth.

Science classrooms are, increasingly, using data collection and presentation applications, such as Vernier's *Logger Pro*, to enrich classroom instruction. These applications, specialized for hands-on research[7], create a real-world environment for students; rather than spending their time to create spreadsheets and enter data, they spend their time analyzing data. The wise teacher keeps this in mind—spreadsheets generally raise more questions than they answer, and a template or graphing tool can focus student attention on important questions and their answers.

As with the word processor and the database, a spreadsheet is relatively easy to use once you have mastered the concept. Once you have learned to use a spreadsheet, teach it to

[7] *Virtual experiments* are also available online and integrated into science applications. These are especially valuable when performing the experiments would involve high-cost equipment or impossible laboratory situations, such as many AP physics or biochemistry lessons.

your students. Software such as Tom Snyder's *Graph Club* provides ready-made lessons for teaching spreadsheets. Sunburst's *Graphers* and Inspiration's *InspireData* include good lesson plans and support materials. Many lesson plans can be found online and in science, mathematics and social studies texts. The alert teacher will find the best ideas, however, in her own curriculum—gathering, organizing and analyzing numerical data are essential literacy components at every grade level. Students at all grade levels like to count, measure and time. Additionally, data sets to support most k-12 studies are freely available in the library and online.[8]

A spreadsheet is often correlated to a hands-on inquiry activity or a project-based learning activity. Because the medium is digital, students who use the spreadsheet to solve a numerical problem can easily manipulate solution sets and predict outcomes.

We are entering an age of data-driven decision making and problem-solving, one in which workers will need data skills in every workplace. Like the database, spreadsheets challenge students to stretch into higher levels of thinking. The seemingly simple choice of chart style (Fig. 6.5) is a thinking decision—What do I want to display? What does my data really mean?

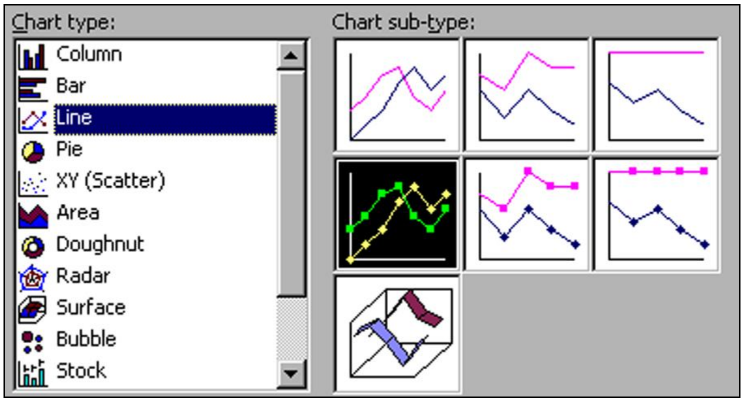

Fig. 6.5 Different styles of spreadsheet charts in *Excel*.

Students charting pH variation in a guppy tank learn quickly, for example, that a range of 1-10 is meaningless. They then need to ask: What is pH anyway and what do these numbers mean? The same students counting guppies and snails will observe that using a line chart allows them to have 7.5 guppies on a Sunday. Is this an accurate presentation of the data? How could there have been half of a guppy in the tank? The teacher guiding this type of learning is not delivering information; she is exciting curiosity and encouraging thinking.

Drawing and Painting—Graphics Tools

Many excellent drawing and painting packages are available for today's powerful computers. Applications such as Adobe's *PhotoShop* and *Illustrator* and Corel's

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[8] Examples would be the US Census Bureau (http://www.census.gov/) and Animal Info for mammal data sets (http://www.animalinfo.org/spec_ind.htm).

CorelDRAW™ or *Painter* can make students who do not think they are artistic feel like birds released from a cage—once they have learned the ins and outs of how to use the software.

Students who *are* artistic may at first feel inhibited by the constraints imposed by a computing environment. But these same artistic students, because of their special talents, will soon learn to make the software sing. Paraphrasing John Vincent Atanasoff, the inventor of the electronic digital computer, you do not need absolute accuracy to achieve relatively perfect results. In fact, full-featured paint programs play a growing role in a graphic arts and technology programs. CAD (Computer-Assisted Design) software, which enables 3D modeling, time-lapse modeling and virtual walkthroughs, is often found in High School arts and technology classrooms, and a simplified CAD program, *SketchUp*, is used in middle schools. The school that makes these applications available will find that they also provide wonderful support for astronomy, geology and many mathematics lessons.

Idea Bank: Draw/Paint Tools

Pictographs
Fun Art—paint animal heads on Metropolitan paintings (they are freely available to schools online)
Lab reports—illustrate and animate the investigation
About Me
Our Neighborhood—archive it in photos
Logos
Make an image Web-Ready—the most powerful use of digital photo editing tools
Alphabet books, step books
Draw/paint as you listen
Draw/paint as you read
Art Class: explore hue and tone, space and negative space, design wallpaper and fabrics
Design a set for the play
Arrange clip art animals (sized appropriately) in a painted biome or habitat
Examine volume in 2D and 3D
Wanted posters for the infamous; star poster for the famous
Tessellations and patterns—plan a quilt, challenge your classmates
Annotate and label blank maps
Storyboard a movie or presentation

Of course, most students will not find advanced tools in the computer lab or on laptops or classroom computers, nor will they need the advanced features of the tools. For the most part, they will be using the more basic tools introduced in Chapter 5. Most educational general purpose and presentation applications contain basic drawing tools, such as those incorporated into the Microsoft *Office* suite of programs and into *HyperStudio*. These offer simple drawing and (this is something to look for) charting features. Simplicity suits the learner's purpose.

Did you know…
There are many file formats in which to save images. The safest are .gif and .jpg. Drawings are best saved in the .gif format and photographs are best saved in the .jpg format. Drawing and paint programs require the teacher or student to **pay attention to format** when saving. This is an essential skill!

A sophisticated program such as *PhotoShop* may well get in the way of learning by forcing the student to focus too much on the technicalities of getting a drawing or photograph perfect.

In any case, all students will come to appreciate a graphic application as a timesaving and creativity-enhancing tool. As is true across the edtech world, finding the best graphics tool for the learning task, and the best task for graphics tool, is the job of the educated teacher.

MacKiev's *Kid Pix*™ program is beautifully designed to allow the youngest children to create artwork in an enjoyable, on-screen environment. This is an example of the new breed of educational draw/paint software. Originally an innovative black & white application, the newest generation of *Kid Pix* includes lively multimedia elements that "grab" students – it even exports animated video to iPods!

Despite its many "bells and whistles," *Kid Pix* develops sound skills by introducing young students to basic drawing and painting tools, at the same time making it possible to for the teacher to introduce or reinforce important concepts, such as symmetry, patterns, and story development.

Another excellent tool is GollyGee Software's *GollyGee Blocks* (http://www.gollygee.com/products/). Designed for education, this application introduces 3D modeling and spatial thinking to elementary students while reinforcing the basic skills needed to use all modern graphics applications. Fig. 6.6 shows a screenshot of a 3D landscape.

The teacher who has the use of a digital camera or scanner is especially lucky. These tools enable students to include digital media in all products, from word-processed documents to presentations. In chapter 5, the uses and value of digital imaging applications such as *iPhoto* and *Photoshop Elements* were discussed. These tools are very student-friendly. Classroom projects centered upon student-taken and student-annotated digital images are a powerful learning experience in any academic discipline.

Similarly, images from the Internet enrich student graphic work, often proving key "starter" or "finishing" elements. One caveat: using images from online sources requires students to follow correct citation rules[9]. Insisting upon this sends a powerful message about intellectual property rights. Teachers should include "correct citation of sources" in all assessments.

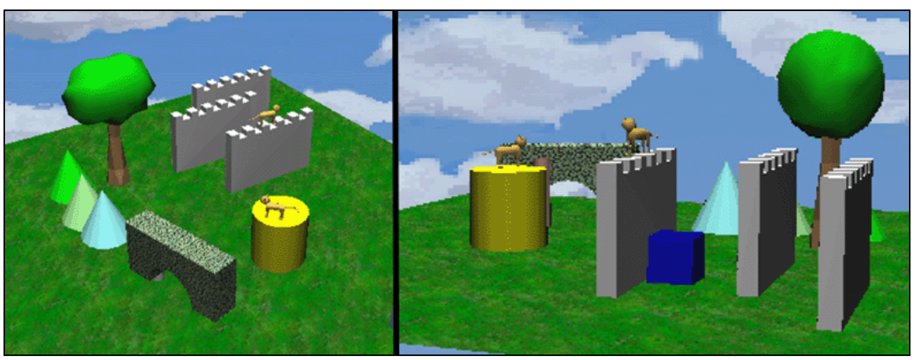

Fig. 6.6 Two views of a landscape—*GollyGee Blocks*

[9] Many educationally minded websites, such as the Metropolitan Museum of Art, allow students to use images without permission - but they do require citation!

Good drawing, painting and special format software enables the teacher to print documents in a range of sizes, from small to very large. Big books can be produced for, even by, the younger age groups. Color maps and other posters also can be printed in large sizes for display on walls in the classroom or around the school. *Photoshop Elements* and *iPhoto* make it possible to print contact sheets of various layouts, saving expensive photo paper. Digital imaging tools, then, empower the student (and teacher) by making it possible to present learning "as I see it," archive this, and quickly revise it.

With the addition of new, free online archiving tools, such as *Flickr* (http://www.flickr.com), classrooms and individual students can also learn to share, document, and safely use digital images. Teachers can create or join Groups to use images for collaborative study. Services like *Flickr* are also a source of images for media literacy units and newsletters.

Authoring or Presentation Software

Presentations pull together all of the elements of student creativity—as their name suggests, they are best used to *present the outcomes* of planning, research, inquiry, or a decision-making exercise.

Apple's *Keynote* is a simple-to-use Presentation application, very similar to Microsoft’s *PowerPoint*. *KidPix* and *Hyperstudio* can also be used for presentations. Slides are designed individually with the help of a template and built-in tools to set the slide background colors and sequencing. Individual slides can contain text, images, animations, sounds, movies, web links. Timing can be automatic or “by clicking.” These are, in a nutshell, the components of any good presentation application.

Idea Bank: Planning Presentation Projects

- Set limits: slides, sounds, transitions and backgrounds, number and color of fonts
- Insist that all elements are collected and organized beforehand
- Insist upon a storyboard
- Practice writing bullet text - follow the 5 x 5 rule
- Practice presenting the presentation
- Encourage students to add "live" drama to the presentation
- Save every step!
- Discourage printing
- Use a rubric for assessment and focus students upon it often

This is such a powerful school medium, in fact, that many of the most-used school applications, such as *Clicker*, *Kidspiration* and *Inspiration*, have added presentation capabilities to new versions. Others have made it possible to see each “page” as a slide in an automated slide show. Moreover, virtually any presentation can now be exported, or archived, as a Quicktime movie or as a web-ready file. Potentially, the audience for any student presentation is global!

Kids of all ages (including college age students) love using these programs because they are easy to use and fun to interact with. A good teacher will take advantage of the motivational aspects to lure students into learning under the guise of having fun! We will examine these presentation tools more closely in the context of multimedia in chapter 10.

It goes beyond saying that *making the presentation* is often the most exiting part of a long-term project. Teachers should make sure that the entire project itself is well-structured in terms of attainable and appropriate learning goals and objectives, and that it allows for enough research or inquiry time. Collaboration is a natural fit with presentations, and this too has to be allowed for. Lastly, the digital presentation is generally just one part of the sharing, or presenting, of learning. Few student presentations are self-contained[10]; most have "real-time" and "real-person" components, often amounting to a mini-lecture. Guiding students in this public speaking exercise is just as important as guiding the digital project.

Graphical Organizers

One of the most widely used educational software applications is *Inspiration* (or its elementary school counterpart, *Kidspiration*)[11]. These two tools have a powerful mission—they organize student thought. Returning again to Jamie McKenzie's insistence upon the importance of Questioning in the learning process, it is not hard to see that a few good questions will yield a plethora of answers, and it is in this dichotomy that the need for graphical organizers lies.

In its most straightforward use, *Inspiration* collects Answers, Ideas, or Details as they are brainstormed. In fact, it contains a tool, called Rapid Fire, to facilitate this. Ideas or concepts can be associated with images from the included clip art library, from a library created for the project, or from the Internet. Students can add hyperlinks and media objects to projects as they do research.

Idea Bank: Graphical Organizers

English - create writing plans, analyze plot, character, theme, mood or tone, collect vocabulary, annotate a text

History - study cause & effect, compare and contrast, organize a research project, analyze a primary document, plan an essay

Math - solve a logic problem, plot the flow of a computer program

Science - visualize cycles, plan a science fair project

Language - create a vocabulary diagram, study a culture or country

Arts - write a How-To, analyze a painting, drama or performance

P.E. - game plans, plot plays

Elementary - alphabet words, My Room descriptions, Venn diagrams, What Doesn't Belong?

All - design and plan a large project

The true power of the graphical organizer becomes apparent when it is time to organize the ideas. Students are able to manipulate the "bubbles" or concept objects in the diagram by linking them, moving them, coloring them and even annotating them with pop up notes. Ideas can be extended by the insertion of sub-diagrams inside of a single concept. Older students will find that the connected outline, created automatically as concepts are added,

[10] A significant exception to this rule of thumb is presentations created as movies (*iMovie, Pinnacle Studio, Flash*) or web pages. The process is the same, but, because they are self-contained, they must be much more content rich.

[11] There are several other tools that are similar in design. *Cmap*, free tool from the University of Florida, has tools for High School. *PicoMap* is a free graphical organizer for PDA's. *Smart Ideas* is an organizer designed to be used with a SmartBoard. *Freemind* is an open source application.

can also be easily manipulated; many learn that it is at times easier to start with an outline rather than a diagram.

As is true of the best education applications, *Inspiration* and *Kidspiration* come with a wide range of useful templates and strong support from the producers, including web-based tutorials, templates, correlation with standards, and idea books.

In the elementary school, *Kidspiration* (Fig. 6.7) is a powerful tool for developing thinking skills such as grouping, sorting, classification, and sequencing.

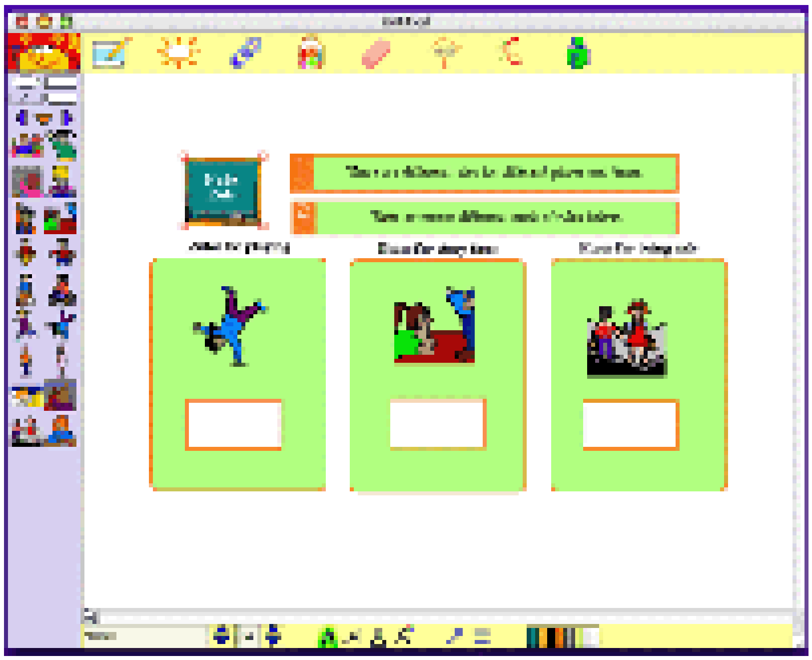

Fig. 6.7 *Kidspiration* makes the organization of ideas easy for elementary school students

Visual tools included in the software facilitate the application of these skills to everyday life and to frequently studied contexts, such as school, home, foods and animals. *Kidspiration*, for example, encourages writing with a built-in word processing tool, to which symbols can be added.

Teachers who require students to use a graphical organizer find that students focus upon the topic, theme or exercise and are less easily distracted by peripheral ideas and

Idea Bank: A Sampling of Online Collaboration Projects

CIESE Online Classroom Projects:
http://k12science.org/currichome.html

The Branding of America:
http://lcweb2.loc.gov/learn/features/branding/

Howard Hughes Medical Institute Ask a Scientist:
http://www.askascientist.org/

The GLOBE Program: http://www.globe.gov/

WISE - Web-based Inquiry Science Environment:
http://wise.berkeley.edu/

Technospud's projects change yearly -
http://www.technospudprojects.com/current.htm

nonessential information. When used to support a collaborative or a hands-on experience, the graphical organizer further encourages questioning and probing—in short, *learning*.

Communications

You will remember from Chapter 5 that communication, including digital communication, can be *synchronous* or *asynchronous*. Synchronous communication, such as face-to-face speech, signing, online chat, phone conversations, or a videoconference, occurs simultaneously between those involved in the communication. Asynchronous communication, such as regular mail ("snail mail"), e-mail, voice mail, blogging, texting, online forums and bulletin boards, is communication that is received some time after the initial message has been sent.

When a broadband connection[12] or modem[13] is used to connect a computer to the Internet, interesting synchronous and asynchronous educational opportunities open up. In this regard, the world of K-12 education is slowly catching up with its big academic brother at the college level and with the rest of the computerized world.

Within the classroom or the school, students can use e-mail, chat and tools shared over the school network[14] to manage group projects, learning how to collaborate in a controlled environment.

Classes of students can also function as "teams," collaborating and peer-editing through wikis, blogs and bulletin boards that extend the school day into all hours. In a growing number of k-12 schools, both in the United States and elsewhere in the world, students are being offered the opportunity for cross-cultural interaction with students and adults from all over the world. Others connect students in real time to remote experts and learning experiences that enrich and extend the classroom experience. Learning in these schools is taking on a reach that extends beyond the school, out into the local and global community.

Computers and communications (C&C) technology has the potential to extend every student's educational experience. As already noted in Chapter 5, it can bring the home into the school and the school into the home, making possible a synergy which has been shown to have a significant impact on the quality of the educational experience for each individual student (Bauch, 1990). But it can also bring the world into the school and the school into the world in ways that are destined to have a profound effect on how education happens.

In the next chapter we will look more closely at the contribution that C&C can make to our students' educational experience. Meanwhile, a useful exercise would be for you to get together with your colleagues or classmates and discuss other ways in which productivity software can further learning.

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[12] Broadband, or high speed, connections are becoming more prevalent in schools. These include cable modems, DSL lines, and T1 lines. With students, speed can be everything.

[13] A modem is a device that converts the digital data in the computer to analog form so that they can be transmitted over the telephone system.

[14] Aquamind's *NoteShare* is an example of such a tool.

TECHNOLOGY TOOLS AND TESTERS: CLASSIFICATIONS OF CAI

Caveat: The Teacher Should Come Bundled with the Software

Caftori (1994) reminds us that children, unsupervised, do not necessarily achieve the learning objectives for which specific software has been designed. The computer does not, and should not, replace the teacher. Good teachers bring diagnostic and motivational skills to the classroom, along with the knowledge and experience to guide children on their intellectual journey.

There are seven categories of CAI, each of which is appropriate under different instructional circumstances and therefore requires a different pedagogical approach. These seven types of CAI are as follows:

- Drill-and-practice
- Tutorials
- Simulations
- Critical Thinking and Enrichment
- Computer-based Laboratories (CBL)
- Programming
- Integrated Learning Systems (ILS)

The ensuing sections clarify the unique characteristics that have made these applications powerful tools in the classroom.

Software for Drill-and-practice

Drill and practice, which is a learning methodology used to reinforce familiar knowledge, is a type of CAI that, in recent years, has received a certain amount of bad press. The criticism in some cases stems more from disparagement of drill and practice as a CAI genre than from dissatisfaction with the effectiveness of the methodology. In its basic form, drill-and-practice is less exotic than other forms of CAI, such as simulations, games, or virtual reality, for example; and thus, from the point of view of the student, less fun[15].

Other criticism comes from a belief that the methodology itself is flawed and basically ineffective as far as higher-level learning. Bigge (1982) points out that, ever since Edward L. Thorndike in the early 1900's debunked mental

Grab Bag: Drill & Practice
Oldies but Goodies - available from CCV Software (http://www.ccvsoftware.com)

Alphabet Express
Blaster (series) - Reading, Math, Spelling, Science
Reader Rabbit
How the West Was 1+3*4
Jump Start (series)
Stickybear Math
Sunbuddy Math Playhouse
Munchers (Math and Word)
Fraction Attraction
Gold Medal Math
Grammar Made Easy

[15] A criticism, as we will see, that software producers and website designers have spent a lot of energy responding to.

discipline as a working hypothesis for learning, there has been a rejection of the idea that the mind can be exercised with a view to strengthening its intellectual capabilities. Drill and practice, Thorndike would say, is not the way to nurture ideas.

Some mental abilities, however, involve skills (remembering a list of items, manipulating numbers mathematically) rather than concepts, and in these cases drill and practice ("mental gymnastics") is clearly an appropriate learning methodology. It can also be argued that drill and practice is, indirectly, as fundamental to the learning of intellectual concepts as it is to the acquisition of mental and physical skills.

With the advent of high stakes testing in all states, drill and practice has taken on a new dimension – and new research studies. In general, these studies find that the individualized nature of the applications increases student interest and learning gains (Kim 2006 and Vernadakis 2005) and that even in non-academic areas, such as social behavior, students can benefit from well-designed CAI. (Miller 2007)

Furthermore, perusal of the Grab Bag titles will show the teacher that all drill and practice applications are now “edutainment” – they are alive with media in all digital forms. Basic is not basic anymore.

Reinforcing Basic Skills So, drill and practice is an important learning reinforcement technique for building basic knowledge. It also is critical for honing the myriad, basic intellectual skills (such as number manipulation, vocabulary use, spelling, sentence construction, following the steps in problem solving, and so on) that are the foundation for higher-level intellectual activity, otherwise known as Higher Order Thinking Skills (HOTS). This is not to say that the computer is always the best vehicle for drill and practice. It depends on the discipline, the circumstances, and the individual student.

> **Did you know…**
> The Internet is an enormous, free, repository of drill and practice exercises. Teachers can mine this resource by doing a Google search for topics such as "math facts games." Furthermore, most textbooks are now supported by password-protected websites that also contain drill.

Computers do, however, lend themselves to fruitful drill-and-practice activity. There are many examples of drill-and practice software that effectively prompt the user to practice, over and over if necessary, the skills required to assimilate a particular skill, intellectual or physical. Good drill-and-practice software will provide the user with an opportunity for repetitive interaction and immediate feedback on the accuracy of responses. It will monitor those responses, moving the user forward if the lesson appears to be well learned, and back if responses indicate that the user is over his or her head.

Using the computer for this purpose is doubly advantageous because students have shown, over and over again, that they enjoy interacting with the computer per se, even to the point of having no objection to doing repetitive work, especially when that repetitive work is disguised in the format of a game. The Minnesota Educational Computing Consortium (MECC), established in 1973 to provide educational computer systems for Minnesota’s schools and since sold, used a game format for its *Munchers* series of drill-and-practice programs. This game format masks the learning that goes on when children match their math, language, and general knowledge skills at a variety of difficulty levels against Muncher-menacing Troggles. Advancing through levels and facing increasingly difficult opponents are components of many drill and practice applications, including *Math Blaster* (Fig. 6.8).

Fig. 6.8 Once a "shoot-em" application, *Math Blaster* now encourages thought and problem-solving as it drills math facts.

Testing It Out It is precisely this level of engagement that critics of drill-and-practice software find objectionable. There is often a fine line between "educational" software and "edutainment" software, a line defined by excessive, distracting *bells & whistles* and by rewards for successful *guessing*. Teachers selecting such software for classroom use would be wise to test it first, all the way through, and with a student at the controls. It is generally possible to write a software use guide or performance rubric that will maximize learning goals and minimize time wasted in "just playing." It is even possible in most applications to take controls away from the student (although studies show that this is not the most effective learning environment for the most needy students!).

Moving into the Future Few educational software developers are focusing their energy on drill-and-practice software alone. The current trend is two-fold: toward "critical thinking" applications that include drill and practice, and toward ILS (Integrated Learning Systems) for the core subjects and skills identified by the NCLB (reading, language arts, mathematics, science), generally focused equally on test-taking skills. These programs will be discussed later in this chapter.

Software for Tutorials

Drill-and-practice software is designed to reinforce known skills, whereas tutorial software is designed to introduce the learner to new skills and concepts. As opposed to ILS, which will be discussed later in this chapter, the tutorial focuses upon a specific curricular content at a specific grade level. In his 2003 review of recent research studies, Kulik concludes that tutorial software (or video) technology can be a "very effective aid" in teaching concepts at both the elementary and the secondary levels (Kulik).

Grab Bag: Tutorial Software

Fraction Shape-up (Merit Software)
Super Tutor Chemistry
How to Read and Understand Poetry
MindForge Fractions
Introduction to Patterns (a Tenth Planet product)
Singing Coach
Velocity and Acceleration
Froguts!
Application tutorials at Atomic Learning (http://movies.atomiclearning.com)

Tutorials take many forms. A student may sit with human tutors who will help him learn a body of knowledge. Or, a student may work with a book that steps him through the exercise of acquiring a body of knowledge. We are interested here in computerized tutorials where a conceptual or skill-based body of knowledge is presented to the user digitally, followed by opportunities to validate the user's comprehension of the concept or acquisition of the skill. The software monitors progress on the basis of the results of validation, taking the user on to new material, or back over old material, in the same way a sensitive human tutor would.

Did you know…
Probably the most used type of tutorial software is used to teach keyboarding! This software is **not** disappearing; in fact, it has gotten better with time.

Moreover…
Probably the most popular tutorials found on the Internet teach **how to use software!** Teachers lacking tech support can make use of these by letting the students teach themselves (and thus each other).

An example of tutorial software is the *Rosetta Stone* language learning systems, which tutor English-speaking students in the learning of French, Arabic, Chinese, German and numerous other languages. Students use the "immersion mode" to learn language through speaking, reading, writing and listening activities. The system also includes drill-and-practice components—a necessary adjunct of language learning.

In the classroom, a skilled French teacher will incorporate a *Rosetta Stone* language learning system into a curriculum that uses many other language learning activities—conversation, drama, reading, writing, recitation, dictation, and a drill and practice application. Computer-based tutorials can thus form just one piece, albeit an important piece, of the puzzle that completes the learning process.

Tutorials can also be used independently by students. Kulik found that students in enrichment and gifted programs often recorded the most significant gains from their use.

Unlike drill and practice applications, then, good tutorials can be used effectively with minimal teacher guidance. The good teacher does, however, monitor student progress!

Moving into the Future Not surprisingly, the Internet is becoming a reservoir for k-12 tutorials, largely through the development of production tools for interactive, multimedia, web-based "learning objects, " such as Macromedia's *Flash* and *Shockwave* movies, *QuickTime* movies, and Java applets. Well adapted to focused topics, these tutorials can provide the teacher with much-needed reinforcement and enrichment activities for home or school. Here is a nice example for the curious: take the Cyber Sports Tour (http://archive.ncsa.uiuc.edu/Cyberia/VideoTestbed/Projects/NewPhysics/page_1.html).

A good tutorial presents the goal up front. It also is enjoyable, thorough, and sensitive to the user's capabilities. Moreover, it either provides immediate and appropriate feedback (similar to that found in drill and practice applications) or provides opportunities to stop and review as many times as necessary. Interactivity is key to user involvement and perseverance. It is no wonder that all aspects of education, pre-k to postgraduate (including medical schools), commercial and public, are embracing this new use of technology for CAI.

Software for Simulations and Gaming

Simulations are powerful tools for learning. They involve the learner in a vicarious experience of events or processes, a kind of "trial run on reality" (Bruner, 1966). As such, they marry nicely into a constructivist or inquiry model of teaching. Students experience something closely related to real life through the simulation, depending on how well it is done. Many digital simulations can be experienced over a network, others are designed to run on individual computers. Both formats lend themselves to collaborative learning, developing communication and interpersonal skills as well as knowledge. Software such as the *Oregon Trail*™, originally created by MECC and now published by The Learning Company, and The Maxis *Sim* series of managerial strategy games—such as *SimLife*, *SimCity*, *SimEarth*, and *SimAnt*—were developed as role-playing games which simulate life in various environments.

There is no doubt that simulation software such as this adds a fascinating, engaging, and virtually realistic opportunity to learn about history, life or scientific phenomena.

Grab Bag: Simulation Software

- Oregon Trail/Amazon Trail
- Hot Dog Stand/Ice Cream Truck
- Sim (series) - Earth, Planet, Farm…
- Eyewitness Virtual Reality Earth Quest
- Invention Studio
- Earth Explorer
- Decisions, Decisions (series)
- The Great Solar Rescue
- Graphing Calculator
- A.D.A.M. the Inside Story
- Virtual Physics Escape from Braindeath
- Sammy's Science House
- Juilliard Music Adventure
- Geometer's Sketchpad
- GollyGee Blocks
- Neighborhood Map Machine

Because of their power to engage the learner, simulations are not new to education. Elementary age students build houses, factories and post offices. Middle school students reenact the Constitutional Convention, stage Medieval Feasts and reenact Plymouth Plantation and Colonial Williamsburg. High school students debate pressing historical and cultural issues. The goal is to help students to develop deeper understandings through total engagement in the activity, the moment, the idea or the event.

Simulations, whether computerized or not, whether tutorial or discovery in nature, are most effective when a realistic range of feedback accompanies the interaction. Commonly available CAI simulations for high school suffer from being somewhat removed from reality by the limitations of a relatively flat computing environment.

When students simulate the dissection of a frog on a computer, for example, they are deprived of the tactile and olfactory feedback experienced when dissecting a real frog in real life. Using the simulation, students learn the correct steps in the procedure, but they miss out on the experience of critical facets of the task. This is all well and good if the students are not expected to go on to become Intel scholars. But if they are, they have to learn in a more realistic environment.

Teachers at the high school level must be sure to select simulation applications that do not "talk down to" students through silly graphics, simplified text, and simplified challenges.

One subset of simulations that does challenge and engage high school students is computer modeling based upon probabilities. Students using tools such *Model-It* from Go-Know analyze the effects of several environmental and random factors upon a population or environment that can be graphed over time. When coupled with a study of actual data, as for the spread of an infectious disease, this is a powerful learning tool.

Simulation applications have existed for many years to support the study of high school mathematics. The "graphing calculator," originally a creator of simple line graphs, is now able to produce animated 3D graphs and visualizations of complex algebraic and calculus equations that respond to student manipulation, graphs that students could not possibly produce by hand.

Simulations can be powerful tools in the elementary and middle school environments, where students have little difficulty suspending disbelief and often become engrossed with software that steps them through a science experiment, an historical sequence of events, a mathematical investigation, a business transaction or a imaginary journey in an impossible place. Along the way the students are prompted for feedback, which monitors understanding and points the way to deeper learning. Simulations are the basic element of the WebQuest, a web-based research and thinking project model that will be discussed in Chapter 9.

In addition to the Internet sites that will be discussed in the next section, an important example of online simulations can be found at The National Library of Virtual Manipulatives (http://matti.usu.edu/nlvm/nav/vlibrary.html), which supports k-12 standards-driven math instruction with interactive simulations (Fig. 6.9 on the next page).

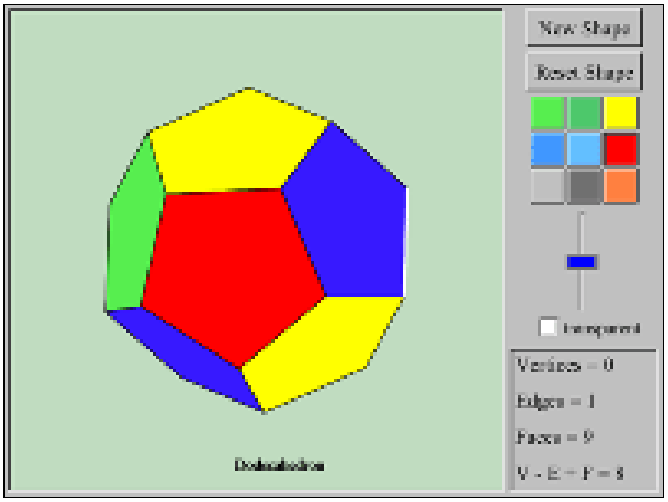

Fig. 6.9 Virtual representation of Platonic Solids

Virtual Field Trips Another interpretation of the concept of simulation is related to what are described as Virtual Field Trips or electronic field trips. Examples of some of the best have been gathered together by Right in Class—Classroom Connections (http://www.rightinclass.com/connections/virtual_tours.htm), which also provides teachers with access to synchronous virtual trips, or live webcams, around the globe. Another list is provided by Kim Foley at Tramline Virtual Field Trips (http://www.field-trips.org/trips.htm). These e-field trips are designed to give the visitor to the website an educational tour of the content. In many cases, the content is tied to state and/or national curriculum standards. Visitors can earn about subjects such as Rainforests, Endangered Species, Salt Marshes, Volcanoes, Shakespeare, Presidents, Pi and so forth. Teachers' objectives and resources for each trip are often provided. The wise teacher will take the tour herself, timer and activity sheet in hand, before introducing it to her class. Some teachers will use a virtual tour of a museum to prepare students for the actual tour, focusing them upon the important exhibits and providing background information.

Moving into the Future—Virtual Reality VR brings simulation into real time. At the simplest level, Apple's QuickTime Virtual Reality (QTVR) program enables the creation of 360° panoramic views of objects. Using the mouse, this application allows you to rotate 3D objects[16] such as molecules, sculptures and photographs.

More and more websites use QTVR in order to display objects related to the content of their pages--museums and art galleries, for example. Perhaps the most exciting educational uses of this technology are 3D tours of real archaeological sites, such as the PBS guided exploration of the Great Pyramid (http://www.pbs.org/wgbh/nova/pyramid/explore/khufuenter.html); and the 3D modeling of virtual chemical models, such as those found at the Biomolecular Explorer 3D (http://www.umass.edu/molvis/bme3d/). VR, then, is a powerful tool across the k-12

[16] Objects have been photographed in a 360º circle or created with 3D modeling software.

spectrum. Note, however, that like most of the other new tools we have discussed in this chapter, VR images are generally accessed over the Internet.

In the gaming and the high-tech training environments, the user often dons headgear or special goggles to view computer generated images of some pre-determined simulation (such as a voyage to the bottom of the ocean or an airplane landing). The player or trainee reacts, via joystick or instrumentation, as if he or she were actually performing the task in the real world. In the modern classroom, students can now use computer keyboards, touchpads and voice controls to manipulate remote cameras and robots and move through simulated environments. Students can get healthy with *Dance Dance Revolution* or control a virtual keyboard using *WII* or other remote technologies. We will have to wait and see whether or not headgear and joysticks become part of the school environment as well.

Virtual Worlds There are a fast-growing number of "virtual" worlds on the World Wide Web, where students have the opportunity to construct knowledge about some segment of the knowledge spectrum by wandering around in a virtual community. One example is Howard Hughes Medical Institute's *BioInteractive* virtual labs (http://www.hhmi.org/biointeractive/vlabs/), where students can participate in a variety of learning modules focused upon medical and biomedical research.

vRoma (http://www.vroma.org/), a virtual exploration of Ancient Rome, is an example of yet another virtual simulation, the MUD (Multi-User Dimension), in which students take on personalities and interact with other "citizens and visitors" to the city. *Second Life* (http://secondlife.com/) is a similar virtual world, in which members move around, create spaces, and interact in the form of avatars[17]. This technology is well adapted to history study, for students, by role-playing "real people" in a highly charged historical place and time (pre-Revolution Boston, for example), learn that the study of history is more than the collection of facts and dates. The line between gaming and virtual worlds is very thin, and teachers should look out for more “game-like” teaching applications in the future.

Did you know…
Teachers can test out the virtual world experience while gaining professional development and networking with colleagues world wide. This is all possible at Tapped In (http://ti2.sri.com/tappedin/), an online community for k-12 educators, librarians and administrators. Check it out - it's free!

Elementary school girls love to explore the virtual world called *Neopia* (http://neopets.com), where they can purchase Neopets, chat, invest in a virtual stock market, and compete against other Neopians. Its success is driving the development of more educational virtual worlds.

There is no doubt that educational computing has barely scratched the surface of potential applications for rich learning experiences of a simulated or virtual nature. The creation of such worlds is time-consuming and a technological challenge, however. For this reason, teachers must rely upon universities, developers and

[17] Not recommended for classroom use, but worth a look!

high-tech institutions to create the content. Furthermore, research findings are tentative with regard to the educational value of simulations in the classroom. Teachers are wise to use them with caution.

In the meantime, teachers who have access to digital production hardware and software can guide their students in the creation of their own simulations and virtual field trips—learning experiences that can then be shared with other classrooms. We took at peek at *GollyGee Blocks* earlier in this chapter, one simple tool for creating virtual spaces, and we will explore more tools in chapters 9 and 10.

Software for Critical Thinking and Problem Solving

A straightforward definition of Critical Thinking (CT) is offered by Ennis: it is "reasonable and reflective thinking focused on deciding what to believe or do." (Ennis, 2002). In his essay, "Critical Thinking: What it is and why it counts," Peter Facione states, "critical thinking came before schooling was ever invented, it lies at the very roots of civilization. It is a corner stone in the journey human kind is taking from beastly savagery to global sensitivity" (Facione, 1998). Powerful stuff. It is no wonder that educators continue to wrestle with how, when, and to what extent CT should find its way into the k-12 curriculum. Increasingly, software and web developers are stepping up to meet this need.

Every teacher learns quickly that guiding students to develop strong Critical Thinking skills is perhaps the most important task of all. In the practical world of the classroom, self-confidence, bullying, harassment and peer pressure are as important as facts. Students must learn to navigate not only their personal worlds, but also the media world and the larger global community, each of which requires that reason, reflection and self-judgment be applied daily to complex and often painful decisions. And yet, because the focus of CT is not just upon solving problems and finding answers, but also upon becoming a better person through doing so, it is difficult to define the exact role of CT applications within the realm of CAI. Although tools exist to measure CT skills[18], they are not part of the assessment toolkit of most elementary and secondary schools; although there are often statewide standards for communication and decision-making, data-driven testing is not in the state toolkit.

That said, good computer applications exist to guide students, generally with the assistance of tutorials and simulations. The software itself, of course, will not teach Critical Thinking, but when used by a good teacher it can support, and sometimes jumpstart, the thinking process.

Thinking skills, like their subset problem-solving skills, can be learned. The development of what is often called "lateral thinking," or "thinking outside of the box," goal setting, and the logical thinking involved in analysis, inference and evaluation are important elements of Critical Thinking. The *Thinkin' Things®* and the *Zoombinis™*series develop these skills

[18] One is the WGCTA, the Watson-Glaser Critical Thinking Appraisal

by presenting students in elementary and middle school with increasingly complex problems to solve—problems that are engaging but also hard[19].

Fig. 6.10 The Zoombinis face many critical decisions

Tom Snyder's *Choices, Choices* series for grades k-5 guides students in "smart" decision making by placing them in realistic scenarios, such as on the playground. The Critical Thinking Company (http://www.criticalthinking.com) produces more traditional software that brings a reasoning approach to the development of mathematics and reading skills, k-12.

Another type of CT software is represented by *The Incredible Machine*. This product requires that students, preferably working in teams, solve a set of design challenges using logical steps. As is often true in the real world, there is no one right way. *MicroWorlds*, LCSI's *Logo*-based application series, requires even more of the students; they must *create and then solve problems* using the *Logo* programming language and a multimedia toolkit. When these problems simulate a rainforest food chain or the attack of a killer virus, the thinking can become critical.

It should come as no surprise that graphical organizers are powerful tools for developing Critical Thinking skills. Brain-storming encourages open-mindedness; mapping a concept or argument visually facilitates its analysis and evaluation. Using a tool such as *Inspiration* along with a WebQuest, reading lesson, history discussion or software application is an effective teaching strategy.

Lastly, you will remember that in Chapter 5 we touched briefly on the use of computer applications to assist teachers with student guidance issues. This too involves CT, and may be the best solution for high school students. Most students today will seek self-help on

[19] As Seymour Paper reminds us in his book *The Connected Family*, the best learning is "hard fun." (Papert, 1996)

the Internet; teachers who familiarize themselves with helpful sites[20] and learn about the advantages and disadvantages of social networking and chatting will, in a quiet way, help students to build Critical Thinking skills. In fact, an open source application, *Ning*, can be used by the teacher (with tech support) to build an in-house virtual world – where the actions that come from thinking can be practiced and (somewhat) moderated.

In sum, it is not the application, but the application of the application that develops Critical Thinking. Any one of the applications or websites discussed in this chapter can become a powerful tool for CT. Returning once again to Jamie McKenzie, it is all about the Questions and, for the teacher, probing for and listening to the Answers.

Software for Supporting Learning

Almost all of the applications discussed so far can be used to *differentiate* instruction. Most can be used at various levels and with a wide range of learning or productivity outcomes.

There is another category of application, however, that can be described as "support software." It exists to make learning through technology accessible to all students, assisting instruction at the point where it is most needed – at the level of the individual student interacting with the computer. We will only introduce some common examples.

Many of these applications are specialized "assistive technology," designed to meet the needs of specific disabilities identified by testing. Software translating a simple two choice input device into an alphanumeric display (writing) is an example of this.

Early readers can use applications such as *Clickr* that prompt the writer with a picture or a word list.

Others, however, operate in the background on most computers – and are used quietly all the time. Because of this, teachers should be aware of these "stealth CAI" applications.

Perhaps the most ubiquitous are the *dictionaries* and *thesauri* contained within applications and also stored as applications on a hard drive. Many other dictionaries can be found online. A related set of applications are the *translators*, used in language classes, but also by ELS and ELL students. Most operating systems make multiple *keyboards* available to support multiple language spellings and characters.

Other examples of support applications are *text-to-speech* and *speech recognition* applications. Both are helpful for the visually impaired and for students with learning difficulties that make reading difficult or tedious. Similarly, *voice recording* applications make it possible for a student who can not easily keyboard to produce lengthy essays or high quality tests.

Teachers must each ALL students in the classroom. Knowledge of these support applications can make the difference between success or failure for many students!

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[20] A good place to start is the Teen Space in the Internet Public Library (IPL), where teens and teachers can find selected sites on topics such as Issues and Conflicts, Health, and Dating and Stuff (http://www.ipl.org/div/teen/). KidSpace is available for elementary and early middle school (http://www.ipl.org/div/kidspace/).

Computer-Based Laboratories (CBLs)[21]

Probes, sensors, digital microscopes and similar data capture devices have long been essential components of scientific experimentation. Their purpose has been to augment the highly sophisticated, built-in, yet inadequate instruments represented by our five human senses. The scientific method, whereby "a problem is identified, relevant data are gathered, a hypothesis is formulated, and the hypothesis is empirically tested" (Webster's, 1991), is applied differently depending on the discipline. But, at its core, it is concerned with the measurement of phenomena through experimentation or repeated observation.[22]

Probing For Data: Data Sensors
(a sampling from Vernier, Pasco and Imagiprobes)

- temperature
- pH
- dissolved oxygen
- angle of rotation
- speed/acceleration
- pressure
- force
- EKG
- exercise heart rate
- voltage
- sound level
- respiration
- humidity
- light

Scientists at all levels recognize the value of the computer-based laboratory (CBL) for research. They have developed hardware and software systems that automate the process of gathering data from experiments, conduct relevant analysis, and produce meaningful reports. We have only to watch *CSI* to learn the impact of speedy data analysis on problem-solving and critical thinking.

Schools preK-12 are using computers to involve even the youngest students in the capture and analysis of considerable amounts of data. In elementary and secondary school laboratories, science meters and probes automate the collection of temperatures, pH and other information, a process that can continue 24 hours a day. As a result, far more experimental data can be collected and cross-referenced than was possible in the days of manual data tracking. One of the most valuable aspects of the CBL is the ability to do real time graphing of data captured in an experiment. Complete data sets can be stored for further analysis and shared over the network or Internet. The collection of physical data, such as the measurement and analysis of images of real objects (leaves, proteins, fibers), is accomplished with digital imaging tools such as the *ScalarScope* and the high resolution digital camera with specialized imaging software such as *ImageJ*. Such images are replacing hand-drawn sketches and the preservation of samples.

It is no surprise that the Internet is a vast resource for science data in all academic areas. Schools lacking hardware resources can perform virtual experiments and mine data sets posted by partner schools, universities and the government. Data analysis is becoming an important part of the global science lesson.

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[21] You will sometimes find these referred to as MBLs, or Microcomputer -based Laboratories.

[22] Encyclopedia Britannica, 1974.

Handheld Laboratories A subset of the traditional CBL is the handheld learning environment, made possible by advances in microcomputing and reduction in the physical size of memory[23]. Most probes and sensors require an intermediary device to interface with the computer[24]. Often this is a PDA, or handheld device. A huge advantage of this technology is its "field-ready" nature. Students participating in one of the CIESE Real Time Data Projects (http://www.ciese.org/realtimeproj.html) or one of the collaborative GLOBE projects (http://www.globe.gov/fsl/html/aboutglobe.cgi?intro&lang=en&nav=1), for example, can complete data sampling exercises, take digital images, enter, merge and graph data in the field. Results can then be downloaded to a desktop or laptop computer, further analyzed, and shared with the global community.

Another hand-held, or rather machine-held, interface is the mini-computer Cricket or RCX brick, central to a robotics program. Probes attached to student-constructed, programmable robots collect "field data" that is downloaded to a computer workstation for analysis. Students can simulate Mars Rover exploration, for example, programming their bots to respond to changes in landscape and obstacles.

One other technology is making its way from the public to the educational sphere. GPS/GIS[25] systems have long been used by hikers, boaters and drivers to assist with navigation, and by archaeologists, meteorologists and rescue workers to plot field data. The availability of satellite images, previously available only to the government, has made it possible for students to learn geography and mapping "in the field" using handheld instruments, many of which have realtime cellular connections. Students as young as elementary school participate in environmental mapping activities and scavenger hunts. These activities not only require that students use the scientific method and critical thinking skills—they are fun!

Another common use of handhelds in the classroom is made possible by the development of inexpensive graphing calculators that interface with, and download directly to, classroom computers. Used originally for high school mathematics, these devices, such as the Texas Instruments TI-89, connect to the same probes that can be used with PDA devices and laptop computers. Courseware is available to support their use in both middle and high school, in both the mathematics and science curricula. Of course, the graphing calculators are powerful microcomputers in their own right. Some schools use *only* handhelds!

Portability is clearly an advantage of the new CBL. Wireless and cellular networks, handheld technologies, voice recognition and digital imaging are making the collection and analysis of real time data accessible to all students. In addition to changing the way we teach, some of these activities may change the way we live our lives[26].

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[23] Just think about the changes in cellular phones over the last five years!

[24] The EcoLog (http://www.dataharvest.com/Products/ecolog/ecolog.htm) is a self-contained unit.

[25] Global Positioning System and Geographical Information System

[26] The newest generation of cellular phones is moving us closer to change!

Programming and Problem-Solving

Interesting discussions have been published on the issue of whether or not computer programming (in *Logo*, *BASIC*, or *Java*, for example) helps develop problem-solving skills—Papert (1980), Turkle (1984), OTA (1988), Capper (1988), Apple Computer (1990), Kearsley (1992), Ennis (1994), to mention but a few. The consensus is that the practice of computer programming does not necessarily help when it comes either to learning problem-solving in general or mathematics in particular. Nor does it help in preparing teachers to teach mathematics. Ennis (1994) concludes, with Lehrer and Smith (1986), Littlefield et al. (1988), and Govier (1988), that "instruction in problem-solving helps facilitate the learning of problem-solving." Period.

Turkle (1984), in the context of child programmers, asks the question: "Do computers change the way children think?" Turkle's answer is another question: "What do different kinds of children make of the computer?" The implication, of course, is that the computer can tell us more about the nature of children (through their mode of interaction) than it can affect that nature.[27] Computer literacy in general is very important from the perspective of employability, but programming per se is only a small part of this employment picture. Current IT skills focus more upon networking, hardware, software, information management and telecommunication tools (such as integrated web-based solutions). Why then teach programming?

Problem solving is a key. Earlier in this chapter we discussed this in terms of Critical Thinking, where it is a component of the universal k-12 experience. Another, real-world answer is suggested by the simple fact that *someone* is doing the programming of every computer application, and this is still considered the most skill-intensive of all IT tasks. Employers who do not find a skilled job pool in-country are seeking it elsewhere. Programming skills are sought-after job skills in the global community.

Logo There does appear to be support for the *Logo* programming language as a medium for developing non-verbal cognitive skills such as creativity and independent learning, described by OTA (1988) as "the ability to monitor and evaluate one's own thinking processes," and the "ability to provide accurate descriptions"—both of which are essential Critical Thinking skills.

You may recall that the *Logo* computer programming language, developed by MIT's Seymour Papert, was a by-product of his work with Jean Piaget, the famous Swiss psychologist and educationist, with whom Papert studied. *Logo's* graphics-based interface, which uses a simulated "turtle" as a vehicle for programmed instructions, is enjoyable, and therefore motivational for children (Kearsley, 1992). This facilitates early introduction to relatively advanced programming concepts, such as recursion (procedures or functions that "call" themselves), variables and conditional statements. *Logo* also indirectly

[27] This brings to mind the common reflection of sports coaches who say that the best place to learn about children's personalities is on the playing field.

motivates the student to think independently along conceptual lines that lead to the acquisition of geometric and other problem-solving skills (Turkle, 1984).

Logo spin-offs, such as the multimedia authoring application *MicroWorlds*, Alan Kay's freeware *Squeak*, and the Lego Logo and MindStorms robotics programs, have renewed the dialogue about the value of *Logo* in the elementary and middle school classrooms by combining its use with the creation of collaborative and student-controlled virtual worlds and simulations. What students program *to learn or explore* is more important than the acquisition of the language itself, to the detriment, perhaps, of future enrollment in AP Computer Science courses (which remain firmly rooted in programming languages, albeit now OOP—Object Oriented Programming).

Logo aside, we have seen in this chapter how problem solving is currently well represented by non-programming computer applications and web-based activities. It would be difficult, in fact, to teach a technology-integrated lesson that did *not* have a significant problem-solving component.

Integrated Learning Systems

The passage of NCLB, as noted elsewhere, has driven the development of standards-driven educational support systems, one type of which is the ILS. The "truly" integrated learning system would be "a system for learning [which] would make available a variety of appropriate activities, well-integrated and well-suited to a learner's interests and capabilities" (Komoski, 1990). About the only integrated learning system that currently fits this description is a good school.[28] A system such as Komoski imagines is too complex to be a reality at this time. In practice, therefore, an Integrated Learning System is a comprehensive networked instructional system comprised of courseware which is integrated with whatever textbooks a school requests, or which replaces selected texts, along with standardized and non-standardized student assessment vehicles which have built-in individual and group student-progress reporting functions.

As Sherry (1992) notes, a good ILS includes courseware for a broad range of learning experiences, including simulations and online or self-contained vehicles for research. Not surprisingly, the ILS is now predominantly an online system.

A growing number of companies offer ILS for this burgeoning market. We will profile the products of two companies: CompassLearning (originally Josten's Learning) and RiverDeep's Destination modules.

CompassLearning Among the most comprehensive ILS's are those offered by Compass Learning Odyssey. These are curriculum modules for every age group from pre-K through 12, providing a standards-based, web-based solution in reading, mathematics, writing, social studies, ESL, special needs and interdisciplinary topics. Not just information delivery systems, these modules provide explorations through texts, experiments, simulations, guided research, and problem-solving activities. In fact, like all good ILS's, CompassLearning Odyssey uses all of the CAI strategies discussed in this chapter. Its goal

[28] Teachers should keep abreast of local and statewide home schooling, distance learning and other "out of classroom" options for students.

is to improve standards-based instruction by teaching to all learning styles and all intelligences.

Activities are largely online, but each module includes offline activities as well. Online assessment aligns learning to state and national standards; individualized reports indicate strengths and weaknesses and suggest remediation and learning paths. Data management is entirely web-based and is accessible to administration and teachers. All facets of the solution can be customized to meet the needs of the school, teacher, or district. Although the solution is web-based, it can be mounted on local servers, allowing the school or district even greater flexibility.

RiverDeep Destination Math and Destination Reading Another interesting k-12 ILS solution has been developed by RiverDeep. Like CompassLearning Odyssey, these provide fully developed curricula in core literacy content areas. Destination Math is a k-12 curriculum. Following an initial assessment, students work through a sequenced curriculum that is correlated to state and national standards and the "top" basals (most used). The math curriculum is delivered in seven modules, each covering more than one traditional grade level. Destination Reading is a k-8 solution focused upon the development of reading skills.

Both RiverDeep ILSs provide individualized assessments and data management and use multiple CAI technologies in the instruction. Unlike CompassLearning, however, the focus of the RiverDeep ILS is clearly to improve standardized test scores.

ILSs such as those described above are not easy to implement in the school. First, they are often cost-prohibitive, although federal funding is available under NCLB and other grants. Second, computers must be available to students, generally in an instructional lab. Next, teachers must be trained to use computers, the Internet and the networks for instructional purposes. Last, teachers must be trained *again* in the use of the ILS. Although most teachers, given the opportunity, will take advantage of an ILS by incorporating aspects of the system into the curriculum, only those with considerable computer background and considerable support will take full advantage.

It is not surprising that Dr. Henry Becker, who has conducted considerable research in ILS, observed that the most effective users of ILS's were teachers who "knew the most about the system, knew the most about what the kids were doing in the lab, and went back to the classroom and made decisions about what to do based on that information" (Mageau, 1990). As with so much computer-based teaching and learning, these ILS have much to offer, but there is still a way to go before they can be incorporated seamlessly into the k-12 curriculum. Technology that *adds to* a teacher's time or *subtracts from* effective teaching is not going to be successful. Teachers should be aware of the current trend toward data-driven education, and thus toward programmed teaching, and apply their own critical thinking skills to its evaluation and implementation.

SOFTWARE EVALUATION

It is important that teachers be able to evaluate the effectiveness of the CAI material that they plan to use in their lessons, even if it has already been evaluated by others. The stamp of approval that someone else puts on an application should encourage teachers to carry out their own evaluations.

Teachers may read reviews of a learning system in a journal; but as pointed out in OTA (1988), journal reviews tend to be positive, if only because they rely on advertising revenue for their survival. Teachers may read sales literature written by the creator or distributor of the system: but this also has the problem of subjectivity. Increasingly, teachers may solicit review and teaching ideas from online colleagues.

No matter what the source of an evaluation, it cannot compare to the evaluation that teachers conduct themselves, for teachers know their students—their backgrounds, their capabilities, their learning needs. Thus teachers can best decide what methodologies will work with students. Teachers must take upon themselves the responsibility to evaluate the CAI they decide to use. Having done so and, in the process, tried out the systems with students, teachers have a responsibility to share their experiences with others—immediate colleagues or, in the broader forum, with colleagues in classrooms everywhere.

The Design of Effective Software Evaluation Instruments

A software evaluation checklist is a prerequisite to the selection of the best from among the rapidly expanding database of available educational software. As with all teaching materials, educational software selection will be affected by the characteristics of the population for which it is intended. For this reason, a software evaluation checklist should be drawn up locally with the help of local teachers and students. In this way, software that is selected will more likely be appropriate to local needs.

A software evaluation instrument is essentially a data entry form. As such its design should reflect the known human factors characteristics of effective data-entry instruments. The following set of guidelines will help in the design of an evaluation instrument appropriate to local needs. Some of the recommendations come from Bailey (1989).

Remember that the people evaluating the software are busy. The easier it is for them to fill out a form that provides useful data, the better. Schools may find that a handheld, web or network-based database facilitates the evaluation process. Others will find that a printed form works best. Here are some basic guidelines for making your own form:

- **Keep it simple** Explain technical terms if necessary. Use familiar words, even local dialect, to make the form easier to read. Keep questions brief. Short sentences are easier to follow than long ones. Make the form easy to fill out; the user should not have to write sentences in response to anything, except, perhaps, for the final open-ended freeform question: "Any other comments?".
- **Keep it brief** The evaluation should be no longer than two sides of a single sheet of paper.
- **Make it easy to follow** Include summary evaluation data at the top of the form to assist in first pass selection—a star rating (with legend), subject area, appropriate

age group. Break up evaluation criteria into categories and use topic headings to guide the user. Use dots or the underscore character to visually align with each question the space allocated for each response. This response space should not be boxed, it should be lined up with other responses, and should be as close to the end of the question as is convenient for easy reading.

- **Make it forward-thinking** A form that can handle the evaluation of web pages as well as software applications will perform an even more valuable function in the future.
- **Make it attractive** Use plenty of white space on the page, especially between sections and between lines. Handwriting needs a minimum 1/4" of vertical height. Depending on the font you use, don't use a point size (the height of the characters) less than 12. Try not to crowd the questions. Top, bottom, left, and right margins should be a minimum 1/2". Use no more than two fonts. The model form in Fig. 6.12 uses a sans serif font for headings, and a serif font for the rest.
- **Make it available** If a hard copy (paper) is more convenient than a digital database, prepare a set of forms on paper and make them available to teachers and students. Have a box nearby large enough to hold 8 1/2" by 11" paper. Also set up an on-line database for easy referral.

The Process of CAI System Evaluation and Purchase

Here are a few recommendations to guide you in the process of software evaluation and/or software purchase. Some of these ideas are drawn from Apple (1990).

- **Plan ahead** Draw up a list of needs: What is the age group and subject area for which the software is required? What criteria may be necessary to fit your teaching style? What kind of CAI software do you prefer for your students? Will it be used in a classroom or lab setting? What hardware and operating system must it run on? Will be used on a network? If so, will it be installed on a server or on individual machines? Will users need ongoing Internet access? Will they need support applications, such as media players? Do you have headphones for student use?

- **Be a "review-worm"** Subscribe to journals (computer or otherwise) and bookmark web pages relevant to your responsibilities and interests in the education field. Scan them from cover to cover. Read reviews of products that might meet your needs.

- **Preview software** Always try to preview software before buying it or subscribing to an online application. Many software producers make demo versions[29] available for download on a website. Seek out local schools that might have the software already if you can Contact the producer directly if you have a question. If you have no opportunity to try out a product on your system, you probably should not buy it.

[29] Demo versions can be either "full featured" or limited. Most will automatically expire, or lock, in 15 to 30 days or after a set number of uses.

- **Check out the software** Always run through the software at least once yourself. Fill out the evaluation form. Then, if you still like it, have other teachers or students use it, too, and get their feedback by having them fill out an evaluation form.
- **Check the license agreement** More companies today are agreeing to let teachers have a copy for use at home (or on a laptop) as well as at school. Site, network, and "lab pack" licenses are also well worth negotiating.
- **Negotiate hard for the lowest price possible** Multiple copies should be discounted. The recommended retail price is rarely the same as the educational price.
- **Purchase educational versions**, not "home versions," where possible. These will contain instructional manuals and standards alignments to support you.

LOOKING BACK

In this chapter, we have examined many aspects of CAI. It is beyond the scope of this book to profile even a tiny proportion of the ever-growing base of CAI applications that are being used to supplements education in our schools. The fact that a piece of software or a website is available for integration into the curriculum does not automatically make it appropriate or effective. Teachers have the responsibility to determine what, if any, applications will be appropriate for their classes. They cannot do this unless they give the technology a chance.

This and the previous chapter have tried to present the characteristics of CAI, along with tools for software evaluation and recommendations for successful incorporation of the technology into the teaching and learning process. But the real work begins when teachers get their hands on the technology and start to "learn by doing." Such an opportunity should be integral to any teacher-education program and, since you are taking this course, it is good that it is part of yours.

LOOKING FORWARD

Chapters 7 through 10 will continue to examine practical aspects of computer-based teaching and learning. The focus in chapters 7 and 8 will be computers and communications (C&C)—networked computing--and its impact on schools, today and in the future. Chapter 9 will examine the tools of online learning. Chapter 10 will then examine all aspects of multimedia.

As will be seen, we have barely begun to scratch the surface of the methodologies for instructional delivery systems enabled by C&C and multimedia technology. Fred D'Ignazio (Bruder, 1992) reminds us that "education is a faddish profession" (like any other), but there are times when it is reasonable to predict that some fads will endure longer than others. Computer technology in the classroom is one of these and, like computer technology in the other professions, it will transform education in ways that may seem beyond our wildest dreams.

Successful innovation in schools cannot happen without strong and enlightened leadership. The best leaders involve everyone—teachers, parents, administrators, and students—in the process of change and renewal. As noted in Joyce (1993): "Two extremely important dimensions of strong leadership" are the ability to generate a collaborative community and the ability to diagnose the essence of problems, solve them, and lead others "to find needs and create solutions." Schools and school districts are almost totally dependent on the quality of their leadership. Superintendents and principals with true leadership skills have shown again and again that ordinary schools can triumph over the most difficult circumstances and compete effectively with the most privileged schools in the world.