Gavriel Solomon states, “A useful tool is one that promotes thinking and cultivates it.” Solomon, author of the article “On the Nature of Pedagogic Computer Tools” in the book *Computers as Cognitive Tools* (S.P. LaJoie & S.J. Derry (eds.) 1993), argues there are two types of cognitive tools. The first type is a performance-oriented tool that exists for the purpose of upgrading the intellectual performance of the learner. Cognition is “distributed” between the tool and the learner to create a product.

The second type of cognitive tool is a pedagogic tool that is less “intelligent” and establishes a clear division of labor between the tool and the learner. The tool is designed to conduct “lower level tedious computational and graphic operations” leaving the learner free to focus on higher order thinking tasks.

Cognitive tools can be described along this spectrum of performance support and learning support. Solomon felt that cognitive tools for education should be of the pedagogic kind and support or scaffold the learner rather than provide expert answers to correct performance. For example, a pedagogic tool provides a guide to help the physician become a better solo diagnostician, while an expert program “corrects [a] physician's diagnostic errors, offering expert-like alternatives and pointing out the most likely diagnosis.”

David Jonassen at the University of Missouri began calling cognitive tools “Mindtools” in the 1990’s. “Mindtools” are “computer applications that, when used by learners to represent what they know, necessarily engage them in critical thinking about the content they are studying.” “Mindtools” include semantic organization tools such as databases and concept mapping tools; dynamic modeling tools such as spreadsheets, expert systems and systems modeling tools; as well as microworlds, which were the forerunners of today’s 3-D multi-user, object-oriented learning environments.

Specific examples of cognitive tools are Columbia University’s computer-based tools for the development and investigation of scientific reasoning skills, the 3-D learning environments for simulated training in emergency medicine developed at the University of Oslo, and modeling tools based on current research in computational physics for high school and undergraduate science classes called the Concord Modeling Workbench. Such use and documentation of cognitive tools supports higher order thinking by distributing the cognitive load of the learner.

*Because of advances in technology, a new book also edited by LaJoie was published in 2000: *Computers As Cognitive Tools: No More Walls: Theory Change, Paradigm Shifts, and Their Influence on the Use of Computers for Instructional Purposes.*

Paula Vincini is an instructional designer with over 20 years of teaching and training experience in post-secondary education.
ILDs: Cognitive Tools at Tufts
By Daniel Cogan-Drew

Ronald K. Thornton is the Director of the Tufts Center for Science and Math Teaching and a Research Professor in the Physics and Education Departments (http://asc.tufts.edu/csmt/html/ron_in.html). Dr. Thornton talks about “Interactive Lecture Demonstration” (ILD). ILD is a teaching technique that uses peer discussion, student predictions, and science demonstrations to increase student engagement through active learning.

DCD: In your writing about the ILDs, you mention the issue of trust: “students [must] understand the experiments and ‘trust’ the apparatus and measurement devices used.” What keeps students from trusting what they see?

RKT: I think there are two explanations. First, the real-time displays give students adequate feedback. People sometimes refer to computers and data-logging equipment as “black boxes.” What distinguishes a black box from special equipment is actually the feedback. If the feedback is sufficient to show the students what’s going on, it builds confidence. The telephone is, in some senses, a black box to you, because you don’t know how it works. Since it gives recognizable feedback, it is a trusted piece of equipment. The same thing happens with the ILD: the feedback that comes from, say, the motion detector makes sense to the students. In an experiment when something different happens from what students expect, they’re not suspicious of the measuring device because they’ve seen it work with things they do expect. The second reason is we begin with things that students know or can learn instantly, and then build on those things throughout the whole ILD.

DCD: You have also been working to expand your content area from physics to chemistry. What are some of the similarities and differences in design between chemistry and physics ILDs?

RKT: We intend to follow the same pedagogical method. However, one of the challenges with chemistry is to figure out what the fundamental things are that students need to know to succeed in this subject. Also, the ability to use representations, like molecular bonding, to do an experiment and show the model is critical. So, we may want to use a modeling software where the students can manipulate these representations and improve their understanding.

DCD: Is the ILD method something that can be applied outside of the sciences?

RKT: I would say it is possible to use ILD in any discipline. Before using ILD techniques, you need either to have done research or know enough about your students to recognize the starting point.

For further information, please refer to: http://ase.tufts.edu/csmt/html/abstracts/physteach.html or http://www.psrc-online.org/classrooms/papers/sokoloff.html.

Daniel Cogan-Drew is the Technology Coordinator for the Education Department and a former high school and post-secondary teacher.

Understanding Cognitive Tools
Compiled by Joyita Ghosh

The following resources will provide an insight on the use of cognitive tools and their applications.

**Learning with Technology: Using Computers as Cognitive Tools**
A detailed discussion about computer-based cognitive tools and learning environments that have been adapted or developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning.

**The Concord Modeling Workbench**
The Concord Modeling Workbench is a set of tools that can be used to compute and visualize the motion of ensembles of atoms and molecules. It also provides an integrating software environment that can be used to easily create, visualize, annotate, conceptualize, cross-link and distribute molecular dynamics models.

**Computer-based Tools for the Development and Investigation of Scientific Reasoning Skills**
This paper outlines a work-in-progress, involving the creation of technologies that foster the development of more advanced internal mental models of causal systems during inquiry, thus improving reasoning competence.

**New Tools in Social Practice: Learning, Medical Education and 3-D Environments**
This article focuses on a specific category of learning environments: 3-D environments. The authors suggest activity theory as a powerful framework for understanding learning activities in different kinds of environments and for informing designs associated with virtual 3-D learning environments.
Instructional Strategies

By Paula Vincini

A computer simulation is a type of pedagogic cognitive tool that, if designed well, allows the learner to focus on higher order thinking. An excellent example is “The Geology Explorer” (http://oit.cs.ndsu.nodak.edu/menu/home.ie.htm), an Internet-based educational simulation designed by a group of North Dakota State University faculty members (http://www.ie.ndsu.edu).

“The Geology Explorer” teaches the concepts and principles of physical geology as student players visit a simulated world, “Planet Oit,” and compete for points by undertaking a goal-directed exploration. During this exploration, students perform simple experiments in order to identify a variety of rocks and minerals.

The benefits of using this cognitive tool include:

- Engaging students in processes that emulate those of a geologist.
- Enabling students to participate in simulated authentic geosciences experiences that might otherwise be impractical in terms of time, cost, and safety (Oit currently contains over 50 locations; nearly 100 rock and mineral types; 200 outcrops, veins and boulders; as well as over 40 instrument and tool types).
- Monitoring student actions through the use of intelligent tutoring agents that unobtrusively intervene when errors are detected.

Anyone with an Internet connection and a browser can visit the “planet,” and there is a low-bandwidth text-based version of the game as well.

“A portion of the landscape of simulated “Planet Oit,” where student players of “The Geology Explorer” can learn to identify rocks and minerals.

AT offers consultation on other effective instructional strategies using technology.

ATHelp: 617-627-2451 or athelp@tufts.edu

“Using Cognitive Tools to Represent Problems”

by David Jonassen, appearing in the University of Missouri Journal of Research on Technology in Education, 2003

Problem-solving in the classroom may not be useful in solving real-world problems, says David Jonassen. Unless students acquire a range of ways of representing and understanding a problem, most will be unable to transfer problem-solving skills beyond the classroom. The solution is to use cognitive tools to present problems in a way that “externalizes” them—making them more visible, palpable or otherwise “real” to the learner.

Jonassen argues that current teaching models have focused on quantitative problem-solving, and the problems presented to students are too neat, or “well-structured,” to be of any relevance in the real world, where variables are often unknown and elements of the problem do not easily translate into a quantitative representation. Even when artificial problems are sufficiently “ill-structured” to approximate reality, learners conditioned to represent problems only one way—usually quantitatively—are not equipped to transfer this knowledge.

The solution, says Jonassen, lies in teaching students to combine quantitative problem-solving with qualitative problem-solving. Learners must develop mental models using multiple representations including “structural knowledge, procedural knowledge, reflective knowledge, images and metaphors...strategic knowledge...social/relational knowledge, conversational/discursive knowledge and artifactual knowledge.” A knowledge of formulas will only be useful to students who can relate the problem to domain knowledge, thereby understanding what formula to use.

One method of promoting multiple representations is to develop cognitive tools that help students externalize “problem mapping,” the ability to model different representations crucial to the holistic understanding of a problem. Jonassen uses the term “scaffolding” to describe the effect of such cognitive tools on problem-solving—a way of providing a supportive framework, or context, for the problem.

Specifically, one type of scaffolding tool is a semantic network, a spatial representation of concepts arranged visually using nodes and lines to demonstrate their interrelationships. A semantic network is useful for integrating new knowledge into an organized framework of domain knowledge. Another type of scaffolding tool is an expert system, an artificial intelligence program designed to provide novices with expert reasoning, helping a problem-solver bring relevant facts, rules and procedures to a problem. Finally, systems modeling, a tool for representing real-world phenomena, enables learners to engage in strategic thinking. Jonassen contends, “Observing the [model] systems that students create is perhaps the most powerful way of assessing the viability and comprehensiveness of learners’ knowledge.”

Genevieve Haas, a part-time freelance writer, is a media relations specialist for Northeastern University in Boston.

By Genevieve Haas
What is GIS and how is it used as a cognitive tool?

A Geographic Information System (GIS) provides users with tools to visualize and analyze spatial relationships in mapped data. For example, a GIS can help one to explore the spatial distribution of data, find out what features are connected or nearby, integrate separate map layers to discover relationships based on location, or analyze change over time and space. A GIS helps one to create hypotheses about spatial patterns. Tufts’ GIS Center has staff available to consult and assist one to create a GIS and perform analyses. The GIS Center has several GIS software packages to help students and faculty with their work. These programs include: ArcGIS 8.2, ArcView 3.3, IDRISI 32, and MapInfo. For more information, contact Denise Castronovo at 617-627-4235, or Rhonda Ryznar at 617-627-3855.

AT Launches New Web Site

Academic Technology has recently redesigned its web site to provide more comprehensive information about the services the department offers to the university community. The site now contains five sections that include detailed information about using instructional technology in teaching, learning and research: Services, Projects, Resources, Events and Publications. It also serves as a repository of previous events, projects and publications that can be stored for future reference. Please visit our Web site at http://at.tccs.tufts.edu.