Constructivist designers develop learning tools and software which is much different than the standard drill and practise or linear presentations we have used in the past. In this section I would like to identify some promising tools based on constructivist ideas.

Perkins (1991) discusses five structures for learning which may or may not be present in a regular classroom. These five include information banks (text or encyclopedia), symbol pads (notebooks, laptop computers) construction kits (Logo, legos, tinkertoys), phenomenaria (area for presenting phenomena and making them available for manipulation; i.e., aquarium, Geometric Supposer, physics microworlds, STELLA, simulations) and task managers (element which sets tasks, helps with execution, and provides feedback; i.e., teacher, computer managed instruction systems). Of these five elements, construction kits and phenomenaria seem to be those elements which would most readily fit into a constructivist learning context. Construction kits and phenomenaria provide a model for many of the new tools being developed to scaffold learners in their quest for meaning.

Other tools being developed emphasize the use of communications or telecollaboration. This thrust is based on Vygotsky's theory of social constructivism, where students construct knowledge based on interactions with others.

Still other tools are developed based on the constructivist recommendations that students learn best in authentic environments, using the complexity and richness of real world examples.

Finally, recommendations have been made that students should be involved in cognitive apprenticeship, where they interact in a subject by being immersed in the area, much like an apprentice would learn a craft from an expert. Polin (1992) discusses these tools by saying that these tools "do not tell you what to know; they show you how to know it. They allow you to be an historian, a mathematician, a scientist, an economist and so on by providing authentic tools and tasks for activity" (p. 6).
One of the first constructivist tools to be presented to the computing world was the Logo programming language. Developed by Seymour Papert as an implementation for Piaget's constructivist theories, this language takes the object oriented structures of a powerful computing language, LISP, and by combining them with a semi-concrete representation of reality, the turtle, allows the student to experiment in a geometry microworld (Rieber, 1991).

Here's a further extension of Logo, the microworld builder. Lego TC Logo allows students to construct mechanisms with motors which are controlled by the computer, just like Papert's original turtle robot. Logowriter incorporates word processing into the Logo environment. You can use the program as a word processor, and you can use Logo turtle graphics to add pictures to the stories.

Lego Logo at MIT: http://el.www.media.mit.edu/groups/el/projects/legologo/

tools menu

**Hypercard**

Another tool with the potential to assist in constructivist knowledge activities is Hypercard. Hypercard can be categorized as a visual database with the ability to form multiple linkages. It can be used as an instructional tool, a collection of pictures or facts, or a front end driver for images on a videodisk player. Hypercard is so flexible and easy to use that it has potential as a tool for student knowledge acquisition, organization and display. One hypercard project, the 'Visual Almanac' produced by Apple Media Lab, is a collection of facts linked to videodisk which presents information on a wealth of different subjects. The interesting part of the Visual Almanac for the constructivist is the ability of students to produce their own linkages between the diverse bits of information in the stack. A special presentation area is available where students are encouraged to produce their own collections of pertinent information, complete with linkages to the videodisk database when appropriate. Here's another link to a [Hypercard Resource Page](http://www.glasscat.com/hypercard/) on the Web.

Hypercard Resource URL: http://www.glasscat.com/hypercard/

**tools menu**

**Science Ware - Hi-C Group Investigation Station**

URL: http://hi-ce.eecs.umich.edu/index.html

ScienceWare is a group of software tools designed for middle and high school students. These tools help with activities such as project planning, data gathering, visualizing, reporting, and building scientific models—all without the need for the advanced mathematical knowledge normally needed for modelling. The tools include:

PlanIt Out - "a collaborative project planning and organizational tool."

NIMBLE - The Newton Interactive Microcomputer-Based Laboratory for Education (NIMBLE) can be used to gather temperature, pH, motion, depth and turbidity through inexpensive probes connected to a Newton.

RiverBank - a database for water quality monitoring which can be easily imported and exported to be shared to other sites.
Viz-It - tool to visualize and correlate data by taking information in spreadsheet form and manipulating it in graphical form.

Classifier - a tool for building classification trees using a questioning process.

Model-It - a tool for creating models and simulations of systems in order to define relationships and test hypotheses about these relationships

RiverMUD - a virtual world built to facilitate scientific modelling, community building and decision making.

Media Genie - a Hypercard stack that simplifies the task of integrating movies, pictures, sounds and multi-media effects into a stack.

Web-It - a tool which takes Clarisworks files and translates them to HTML format for use on the web.

Science Learning In Context

Planet Earth Tricorder (PET) - a tool for environmental data collection and analysis.

Knowledge Integration Environment*

URL: http://www-cscl95.indiana.edu/cscl95/bell.html

The Knowledge Integration Environment was designed to demystify science. It responds to research showing that science courses confuse students by contradicting "everyday" observations. Students respond to these contradictions by concluding, for example, that objects in motion come to rest at home but not at school, or that light dies out at home but not at school. Science courses need to help students reconcile these contradictions, and guide students to distinguish between technical and colloquial usage of science vocabulary. To help students gain an understanding of science, students need to make connections between scientific concepts and relate these concepts to personally relevant situations and problems.

Here's an example of KIE: http://www.kie.berkeley.edu/KIE/web/hf/index.html

To do this, the Knowledge Integration Environment includes:

- "KIE Tool Palette"--an interface component that allows navigation of the system
Constructivist Tools

- **Netbook**—a Net-oriented notebook that allows student groups to organize, analyze, and author evidence;
- **Networked Evidence Databases (NED)**—collections of scientific evidence both from the Net and created by students, organized by science topic and activity;
- **SpeakEasy**—a multimedia discussion tool which allows students to conduct structured conversations about their scientific ideas over the Net;
- **Student Knowledge Integration Planner and Profiler (SKIPP)**—a teacher tool that allows users to design Net-oriented activities for their students, as well as identify and customize activities for individual students based on their proficiencies and interests; and
- **Knowledge Integration Coach (KIC)**—an on-line guidance system which provides supporting prompts and feedback as students work on activities."

**tools menu**

**VIEW: Video for Exploring the World**

URL: http://ousd.k12.ca.us/netday/links/Action_Research/about.html

By using video as a data collection device, students can explore aspects of the world, such as the behavior of dunked basketballs, toy trains, and jump ropes. The VIEW project is exploring different ways video can be used to collect data and is designing tools to extract point, line, angle, and area measurements from video. Analytical software with which students can manipulate data, generate graphs, construct mathematical models, and predict graphical patterns is also used. Students can also record and analyze their own video.

**tools menu**

**Tabletop**

URL: http://www.terc.edu/TEMPLATE/products/item.cfm?ProductID=39

Tabletop is a new-generation data software tool that provides dynamic visual representations for organizing, exploring, and analyzing data.

**tools menu**

**Learning Sciences Program**

http://www.ls.sesp.northwestern.edu/research/
The Learning Sciences program prepares masters and doctoral students to become engaged in the scientific study of teaching and learning. "Current themes of research in the Learning Sciences include:

- Technologically-supported learning by doing environments.
- Learning and teaching in cultural and social contexts.
- Cognitive models of reasoning, learning, and problem solving.
- Environments for Inquiry-based learning in mathematics, science, and literacy.
- Changing roles and preparation for teachers involved in innovative design and practice."

Current research and tool projects include:

**Biology Guided Inquiry Learning Environment (BGuILE)** - a learning environment for high school biology which includes a computer-based learning environment and classroom activities emphasizing multiple modes of inquiry.

**Collaborative NoteBook** - designed to support communication of students, teachers and mentors across time and space and outside of normal class time. The Collaborative Notebook is a shared internet database. Students also have private notebooks, or can create a group notebook for a project. The Notebook is also used in the CoVis project below.

**Learning Through Collaborative Visualization (CoVis)** - this project includes desktop videoconferencing, shared software for remote, real-time collaboration, internet access, a multimedia scientist's notebook and scientific visualization software. The purpose of this project is to provide students with the same tools as scientists for the study of atmospheric and environmental science.

**The SIBLE Project** - The Supportive Inquiry-Based Learning Environment has developed software titled the Progress Portfolio. This software is used to develop, support and assess science projects. The goals of the software are as follows: manage complexity, monitor progress and understanding, and facilitate reflection about their investigations.

**The SSciVEE Project** - this project supports scientific visualization to enable students' understandings about complicated science concepts such as climate and weather. The software, ClimateWatcher, gives numerous measurements of those factors important to climate. Concrete measures are also included which make it easier for students to understand how climate works.

**WISE (Web-based Inquiry Science Project)** - WISE is a simple yet powerful learning environment where students examine real-world evidence and analyze current scientific
controversies. Our curriculum projects are designed to meet standards and complement your current science curriculum, and your grade 5-12 students will find them exciting and engaging. A web browser is all they need to take notes, discuss theories, and organize their arguments... they can even work from home! Our Teacher Area lets you explore new projects and grade your students' work on the Web. Best of all, everything in WISE is completely free.

Phenomenaria and Virtual Worlds

Space Shuttle Commander

Rieber (1991), discusses a project which teaches students about Newtonian physics using the Logo dynaturtle. In addition to the regular turtle characteristics of distance and direction, a dynaturtle also has velocity. The dynaturtle is used to explore motion in a simulated frictionless, gravity-free environment. This project, Space Shuttle Commander, places the student at the helm of a space shuttle, with responsibilities for navigation and docking with other objects. Students learn aspects of Newton's laws of motion while manipulating the shuttle in the microworld.

tools menu

ScienceSpace"

URL: http://www.vetl.uh.edu/ScienceSpace/absvir.html

"ScienceSpace" is a collection of virtual worlds designed to aid students in mastering challenging concepts in science. ScienceSpace has three worlds, NewtonWorld, MaxwellWorld, and PaulingWorld. "NewtonWorld provides an environment for investigating the kinematics and dynamics of one-dimensional motion. MaxwellWorld supports the exploration of electrostatics, leading up to the concept of Gauss' Law. PaulingWorld, the most recent addition, enables the study of molecular structures via a variety of representations."

"Data has been collected on usability and learning through questionnaires, pre- and post-tests, in situ prediction and experiment, and post-session interviews. The results are not uniformly conclusive but suggest that students can improve their mastery of abstract concepts through the use of virtual environments that have been designed for learning."

(Chris Dede, Marilyn Salzman, R. Bowen Loftin)

tools menu

Investigating Lake Iluka
Investigating Lake Iluka is a CD-ROM-based multimedia ecology simulation. In this program, students can collect biological, chemical and physical data from a range of ecosystems. Case studies of scenarios are presented by media reports and used for inquiry and problem solving. The program is intended to develop a broad array of scientific investigative skills. It includes the generation of a custom report.

Metacognitive support is provided in the following ways: a) cognitive self management is enhanced by having a variety of media sources, some relevant and some not, and students need to choose those germane to their investigation; b) prompting and hints accompany the problems; and c) the experience of experts is provided in the form of a reference book and various media reports (students must critically analyze the hidden agendas of all sources when forming conclusions). Hedberg et al.(1994)

**STELLA**

STELLA (Structural Thinking Experimental Learning Laboratory with Animation) provides an icon-based toolkit for modelling dynamic systems. Models can be built in many subjects (i.e., chemistry, physics, social studies) while STELLA looks after calculations and records results. Students can develop their own models of the way things work and so test dynamic hypotheses about the ways systems operate.

**Telecollaboration and Computer Mediated Communication**

**Bubble Dialog**

Bubble Dialog was designed by the Language Development and Hypermedia Research Group (McMahon, O'Neill and Cunningham, 1992). They have employed the metaphor of Open software which is "largely empty of content, but designed to be flexible enough to fit within the context and learning goals of the user, open to simple and timely customization" (p. 44). Their Bubble Dialogue program uses pictures of cartoon characters in a situation to promote a dialogue between younger students. The students have to type dialogue into bubbles above the characters' heads. Each dialogue exchange consists of a spoken bubble above one character and a thought bubble above the other. The next scene will reverse this pattern, with the second character speaking and the first thinking. In this way, students are encouraged to separate unspoken feelings from spoken communications. Again, this tool applies the constructivist view that meaning is a socially negotiated process, and can be used to encourage the
understanding of multiple perspectives.

tools menu

Round Table

Goodrum and Knuth (1991) have developed a tool for critical analysis called Round Table. According to the authors "the RoundTable environment attempts to support the following processes in a social environment: comprehension, idea generation, analysis, composition, reflection and communication." (p. 5) Although many of these tools are available commercially (as groupware and electronic mail) the authors felt the need to reproduce their functions together in a more consistent format where the tools would work in a collaborative integrated environment. The project is very interesting and the student comments show some of the flavor of constructivism when it comes to the social negotiation of meaning. One student mentioned that they really got different perspectives on the case study they were examining when they could see other students' comments without having to wait their turn to talk. They could concentrate on what was being said, instead of worrying about when their turn for talking was coming. They could also type their comments at any time, without waiting for someone else to be done theirs. The argument analyzer is a component which has the student examining various people's perspectives in a case study. One student commented that that tool really encouraged dialectical thinking, by requiring the user to look at the same situation from varied perspectives.

tools menu

Judi Harris' Telecollaborative Projects

Professor Judi Harris of the University of Texas at Austin has been a phenomenal resource person for activities and projects fostering information sharing and knowledge construction over the internet. Below you will find links to many of these projects. The Electronic Emissary site connects students with knowledgeable resource people. The telecollaborative projects range from keypals to extensive problem solving activities designed to allow students to construct knowledge. The Activity Structures provide the conceptual framework for the projects.

Judi Harris' Virtual Architecture: http://ccwf.cc.utexas.edu/%7Ejbharris/Virtual-Architecture/index.html

Electronic Emissary Home Page http://emissary.ots.utexas.edu/emissary/index.html

tools menu
CSILE (pronounced see'-sill) Computer Supported Intentional Learning Environments*

URL: http://csile.oise.utoronto.ca/

"CSILE is the first network system to provide across-the-curriculum support for collaborative learning and inquiry. At the center of the CSILE software is a communal database, created by students and their teachers. Students can enter text and graphic notes into the database on any topic their teacher has created. All students on the network can read the notes and students may build on or comment on each others' ideas. Authors are notified when comments have been made or when changes in the database have occurred. Various note formats and supports are designed to enhance the potential of the communal database for collaborative knowledge-building." (Centre for Applied Cognitive Science at the Ontario Institute for Studies in Education of the University of Toronto (OISE/UT)) A new version of CSILE, called Knowledge Forum is commercially available.

Testbed for Telecollaboration*

URL: http://teaparty.terc.edu/

Testbed for Telecollaboration is investigating how to use the resources of Internet for collaborative inquiry -- students at distant sites work collaboratively to collect, organize, and analyze data and share their findings with others. This undertaking has two major goals. First, to organize collaborative inquiry projects designed to explore the benefits and barriers in using telecommunications, and second, to design technology that supports the use of telecommunications in education.

Kidspace*

URL: http://www.education.com/kidspace/

Kidspace is an online support designed for student construction, reflection, and discourse in language arts. It is composed of 4 different areas: Captain's Log, Communications, Cricket Village and Exploratory Missions. Cricket Village is a space for students to explore dialog and narrative. Exploratory Missions provides students with a writing space in which they can develop a poem, story, report, or commentary. Captain's Log and Communications are used to comment on other students exploratory missions. Captain's Log is a private journal, while
Communications allows students to comment on others' work.

**Kidlink**

URL: http://www.kidlink.org

Kidlink is a grassroots project aimed at getting as many children in the age group 10 - 15 as possible involved in a GLOBAL dialog. Students must register and can participate in conferences or projects with other students around the world.

**Cognitive Apprenticeship**

**POV**

Point of View (POV) by Scholastic is a history processor. Source documents, numerical data, digitized sounds and images and a timeline are all part of this program. Thematic sets (daily life, science, reform and protest, and many others) allow students to explore history from many different perspectives. Ready-made presentations give students a linked view of an era. The ability to create additional presentations and place their own links extends the program further. At the highest level of difficulty, the student must function as an historian, deciding what information is credible and importing it into a database. POV is designed to allow students to carry out a whole meaningful task and see the big picture of history from its many perspectives.

**The Perseus Project**

URL: http://www.perseus.tufts.edu/

"Perseus is an interactive database of information concerning the Ancient Greek world. The database contains texts (complete works of thirty authors), images (25,000 pictures of vases, sculptures, coins, and architecture), and reference materials (atlas, encyclopedia, Greek-English Lexicon, Greek, English, and object keyword searches for entire database)."
**JASON Project**

URL: http://www.jasonproject.org/

"The JASON Project was founded in 1989 by Dr. Robert D. Ballard following his discovery of the wreck of the Titanic. After receiving thousands of letters from children who were excited by his discovery, Dr. Ballard and a team of associates dedicated themselves to developing ways that would enable teachers and students all over the world to take part in global explorations using advanced interactive telecommunications."

Each year the JASON Foundation for Education sponsors an annual scientific expedition. During the expedition, students can take part in live, interactive programs which are broadcast to educational, research, and cultural institutions in the United States, Mexico, Bermuda, and the United Kingdom. The key educational components of the project include distance learning technologies, innovative curricula, online systems, community based partnerships and teacher professional development programs.

**MayaQuest**

URL: http://quest.classroom.com/maya2001/

MayaQuest is a software program on CD developed to teach students about ancient Mayan culture. The CD contains multiple paths through the material, including a virtual reality tour of Mayan ruins and a database of artifacts and information. What makes MayaQuest a really valuable experience is the telecommunications aspect of the course. For several years, students have been able to follow along as a team of scientists made a bicycle trek through the jungles to different remote archaeological sites. Along the way, this team would beam back regular reports about their trip, people they encountered, and information about the jungle. Students were involved through satellite uplinks and were allowed to ask questions of the researchers and of local people.

**Study Support Environments**

The Institute for Learning Technology at Columbia University has worked closely with the Dalton School to design Study Support Environments. These environments are designed to provide a supportive environment for students as they construct their own knowledge.
Archaeotype

Students study ancient Greek and Roman history by observing simulated archaeological sites. Teacher modelling is strong at first (consistent with the cognitive apprenticeship model) and becomes less and less as students become more confident in their shared interpretations.

tools menu

Situated Authentic Learning

The Adventures of Jasper Woodbury*

URL: http://peabody.vanderbilt.edu/projects/funded/jasper/Jasperhome.html

The features of this program include a narrative video presentation with embedded data design where students must decide what information can be useful in solving the problem posed, and what information is extraneous. The problems are engaging for students, and they mimic the complexity of real life, where problems are messy, and defining the problem can sometimes be harder than solving it.

tools menu

Voyages of the Mimi*

URL: http://www.sunburst-store.com/cgi-bin/sunburst.storefront/3b04b1ce0b012bf42717d00b8932063a/Product/View/6920

The Voyages of the Mimi were developed by Bank Street College in 1985. They feature multiple CD-ROMs which take students along on a sailing ship which is studying whales off the coast of New England. The videos switch between a fictional story of people studying whales and actual accounts from scientists involved in the same activities. The series also includes software which allows students to carry out some of the experiments done by the crew, as well as learn about marine ecosystems. The Second Voyage of the Mimi focuses on archaeology and the culture of the ancient Maya.

tools menu

National Geographic Society's Kids Network

The National Geographic Society's Kids Network is a telecommunications-based, hands-on science and geography curriculum for grades 3-7 and offers students and teachers the chance to
work with leading scientists. Via on-line communication, children have access to curriculum units in the sciences (Hello!; What's in our Water; Weather in Action; Solar Energy; Too Much Trash?; Acid Rain; and What are We Eating?), in which they collect data, run experiments, and share the results throughout the worldwide network.

**tools menu**

**New Additions**

**Genscope** - GenScope is a learning environment that uses the computer to provide an alternative to text-based science education. It provides teachers and learners with a new tool that enables students to investigate scientific and mathematical concepts through direct manipulation and experimentation.

**Geology Labs Online**

**Researcher** Researcher is a software tool that provides students with a collaborative environment in which to plan, implement, and document their classroom research projects. Researcher helps students keep track of key information during every phase of the research cycle.

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**Articles referenced:**

Hedberg, John G. and others. (1994) Information landscapes and exploratory user interfaces: Redesigning to improve learning outcomes. Eric document # ED 373717


*All items marked with an asterisk have been paraphrased or directly quoted from the linked web site listed underneath each tool.*