WEBTANKS: TOOLS FOR LEARNING BY DESIGN

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This paper describes a collaborative Web environment, or Webtank (think tank on the web) to support student learning by design. Targeted for high school students in a newly developed cross-disciplinary science and technology curriculum, it supports students in their design and invention projects. The paper describes results from a pilot test of the curriculum and additional student brainstorming sessions on "designing a Webtank to support design."

The Webtank serves three learning functions, as a:

- Series of prompts to help student designer and inventors generate innovative, integrated design concepts and new inventions. Webtank prompts the thinking of individual students on their projects.
- Framework to facilitate collaboration, where students interact with other students around issues that arise as they design their projects and integrate their individual projects into a larger, collaborative project plan.
- Way to structure archives and resources in order to retrace creative processes that have occurred in this environment. The Webtank provides a vehicle for researchers to observe design and collaborative problem-solving in action.

I use the term Webtank to refer to a Web environment that supports think-tank activities. Webtanks enable distributed collaboration using available Internet technologies and bandwidth. A key question: How can the design of the Webtank be informed by human design and collaborative problem-solving processes, and at the same time provide a way to observe and better understand those processes? This chicken-egg question demands an evolutionary development strategy.

NASA Ames Research Center and the Research Institute for Advanced Computer Science (RIACS) are developing a think tank supported by a Web environment to spur NASA cross-disciplinary collaboration. In order to test some Webtank ideas in a near term application, I began to collaborate with SETI on the last Evolution of Technology module in their cross-disciplinary high school science curriculum (physics, chemistry, biology, and evolution of technology). This paper describes one Webtank application for a high school cross-disciplinary science and technology curriculum and considers what can be learned from that experiment that may be applicable to intranet e-learning in general.

APPLICATION IN A CROSS-DISCIPLINARY SCIENCE CURRICULUM

The primary objective of the Webtank is to provide an "intelligent framework" to guide and record the thought processes of "students as designers and inventors." Students at the Harker School in San Jose, California are also taking part in hands-on brainstorming sessions on how to design a Webtank to support design. The Voyages Through Time (VTT) pilot test took place in January 2001. Input from this test is being used to redesign the field test, which takes place during the 2001-2002 school year. The VTT Webtank experiment will feed into development of a prototype Webtank for a NASA think tank. So SIGGRAPH 2001 occurs at an ideal time to involve members of the SIGGRAPH community who are interested in questions such as

- How can we design a webtank that is truly interactive, with the capacity to "self-organize" as it scales up, and the potential to expose students to other outstanding student work?
- How can the Webtank become an experimental vehicle to explore how intranets can support various types of networked learning?

This paper demonstrates the intranet architecture for the Webtank, explaining how it serves two complementary functions: providing process support for invention and collaborative problem-solving (active mode) and offering a knowledge-management framework for information resources and project archives (passive mode). Users can click back and forth between active and passive modes. I describe how the TRACE cycle, a cognitive model, enables this complementarity between the active and passive modes.

In the active mode, a Webtank Integration Broker serves a brokerage function for collaborative transactions, enabling students to introduce their project ideas and find other students with whom they can work on a "bigger picture" that combines multiple projects. In the passive mode, completed individual Web entries are evaluated and archived with multiple mechanisms for search and matching by the Webtank integration broker, and a knowledge-management framework to grow the knowledge bank organically. The first SETI implementation focuses not primarily on the technology but on design of the interface and knowledge-management system.

The Webtank as a Curriculum Development Tool

The Webtank is a tool not only for the students and teachers who use it for design projects, but also for curriculum designers, who can use it to respond to student needs as indicated in Webtank records of their performance. The Webtank is designed to support three approaches to learning:

- Learning by seeking information as needed to develop a plan (project-based learning).
- Peer-to-peer learning through sharing ideas in a collaborative Web environment.
- Learning through synthesis, so that all students understand where their contributions fit, and how can they can be integrated, into a bigger picture.

The Webtank is designed to grow as it supports students to generate novel ideas for their new technology design, and documents their projects as resources for other students.

Edwin Hutchins has advocated creating a synthetic network and observing how consensus is attained in such a network. In contrast, my focus is on how convergence can be achieved in real group problem-solving and how such a process can be supported in a Webtank environment. Yale University professor Irving Janis studied why committees fail by analyzing a number of case studies from public policy. His observations of the dynamics of group process should inform Webtank design. In *Groupthink: A Psychological Study of Policy Decisions and Fiascos*, Janis analyzed a series of major public policy blunders and showed why groups notoriously produce decisions that are more foolish than what their individual members might have produced alone.

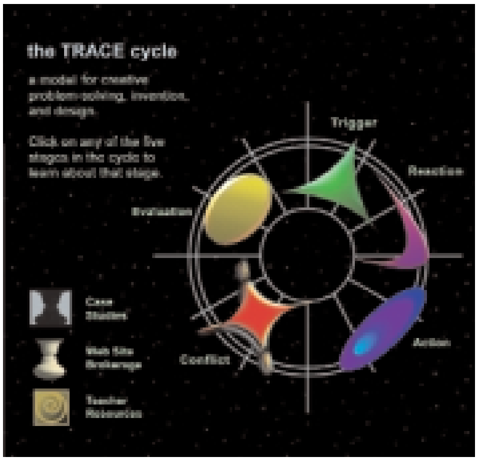
Though Janis' case studies preceded the widespread use of Internet and collaborative tools, by highlighting the importance of the individual in collaborative decision making, they provide insight for today's Webtank designers. Janis showed that, because of pressure for consensus, the intelligence and effectiveness of the individuals in the group had little to do with the effectiveness of the group as a whole. If Janis was correct in stressing the importance of each individual's perspective in group process, then a Webtank to support self-directed learning and innovation will require mechanisms to retain individual identity within the larger group process. Drawing an analogy between collaborative problem-solving and evolution supports this position. Having a lot of cells doesn't make an organism complex; it's still just a lot of cells. Differentiation is a prerequisite for complexity and individually motivated learning.

A framework to support your invention process and collaboration with others (the faces)

A storage container for information, resources and archives of other projects (the vase)

CLICK ON THE VASE TO SWITCH TO ARCHIVES/KNOWLEDGE MANAGEMENT

Dual portal to the Webtank's complementary functions: process support for invention and collaboration (active mode: click on the faces) and knowledge-management framework for information resources and project archives (passive mode: click on the vase). Users can click back and forth between active and passive modes.



a model for creative problem-solving, invention, and design.

Click on any of the five stages in the cycle to learn about that stage.

Portal to the five stages of the TRACE model, each of which offers prompts to support and guide student designers and inventors.

Conclusion

Webtanks can address three prerequisites for shifting the passive delivery paradigm by supporting demand:

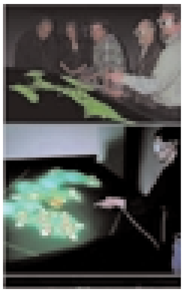
- For more student-directed learning by doing.
- To pioneer new ways to use the Web in innovative learning environments.
- For research on collaborative problem solving using the Webtank to gather data.

This third demand uses the Webtank as a petri dish to culture the creative process, so that “invisible observers” can watch how students perform in this environment. Though any theory about the creative process is hard to prove, my premise is that a partial correlation can be drawn between individual creative process (which is unobservable) and group processes of design and concept formation, where the process of invention is open to view. Using the Webtank to support learning by doing raises a range questions:

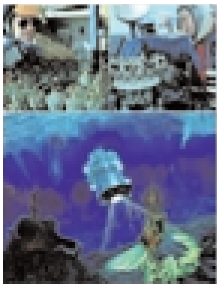
- How can we pioneer new ways to support self-directed learning?
- How can we support new forms of student collaboration across distance and through time?
- How can we create a growing repository of student projects to inspire future generations of students and address the knowledge-management challenge of “scaling up?”

Webtanks can not only support cross-disciplinary groups as they develop new concepts, but also track these work sessions as case studies in cross-disciplinary learning and innovation.

Zann Gill (MArch Harvard) is a research scientist with the Research Institute for Advanced Computer Science, where she is responsible for program development for the Ames Institute for Advanced Space Concepts (a think tank). Various NASA enterprises have identified the need for more effective methods to promote cross-disciplinary collaboration. Her research focus is on evolutionary models for design and collaborative problem solving. She has collaborated with SETI and the Harker School to test ideas for how a Webtank can be used to promote collaborative problem solving in a learning environment.



Group challenges require students to integrate many components into a coordinated design strategy or plan. Two images of the immersive workbench at NASA Ames Research Center. Virtual Mechano-Synthesis software by Chris Henze allows designers and researchers to simulate and visualize new molecular combinations for drug design. In a simulation, we can see patterns that we did not see in the data alone. So visualization gives us another problem-solving tool. Students are asked to explore how new tools may change our ways of working in the future.



Group challenge to imagine how new visualization tools will change the way we work in the future. Students choose an earth environment (for example: ocean, desert, Arctic, Antarctic) and design an expedition to test methods and technology for a future Mars mission. In an ocean-analog mission, students simulate a mission to Jupiter’s moon Europa, using the TRACE model to guide their collaborative problem-solving process. Conflict and Evaluation are two key stages of the five-stage process.