Alien Rescue: A Problem-Based Hypermedia Learning Environment for Middle School Science

Min Liu
University of Texas at Austin

Doug Williams
University of Louisiana at Lafayette

&

Susan Pedersen
Texas A & M University

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Correspondence sent to: Min Liu
Dept. of Curriculum & Instruction
University of Texas - Austin
Austin, TX 78712
Email: MLiu@mail.utexas.edu
Tel: (512)-471-5211

ABSTRACT

This article describes an innovative hypermedia product for sixth graders in space science: *Alien Rescue*. Using a problem-based learning approach that is highly interactive, *Alien Rescue* engages students in scientific investigations aimed at finding solutions to complex and meaningful problems. Problem-based learning (PBL) is an instructional strategy proven to be effective in medical and business fields, and it is increasingly popular in education. However, using PBL in K-12 classrooms is challenging and requires access to rich knowledge bases and cognitive tools. *Alien Rescue* is designed to provide such cognitive support for successful use of PBL in 6th-grade classrooms. The design and development of *Alien Rescue* is guided by current educational research. Research is an integral part of this project. Results of formative evaluation and research studies are being integrated into the development and improvement of the program. *Alien Rescue* is designed in accordance with the National Science Standards and the Texas Essential Knowledge and Skills (TEKS) for science. So far *Alien Rescue* has been field-tested by approximately 1400 sixth graders. More use in middle schools is in progress and more research on its use is planned.

INTRODUCTION

In its report, *Preparing Our Children: Math and Science Education in the National Interest*, the National Science Board (NSB, 1999), the governing body for the National Science Foundation, pointed out an alarming fact: US students are lagging behind other high-performing countries in math and science, especially at the middle school level. It stated, "Deficiencies in mathematics and science have become a barrier to higher education and the 21st century workplace." The evidence of a shortage of a qualified workforce is already observed in different sectors of today's economy, especially in the high-tech industry. At the heart of this problem is the lack of interest that students show toward the instruction presented in school. Some educators suggest that this is a result of the instructional materials that fail to provide a supporting context and lack real-world implications. Because students do not see any value in the information presented beyond its place on the next test, they are not able to fully incorporate it into their own knowledge base. The NSB recognized this as a problem of national importance, and recommended that this problem be addressed through the provision of quality instructional materials at all levels.

Technology is widely used to enhance the delivery of instruction. Computer technologies have the potential to offer rich learning contexts needed to promote academic success for students at different levels (Jonassen, 1996). Although there are numerous educational software packages on the market, instructionally sound software is lacking, especially at the middle school level. Software guided by educational theories and research is hard to find. Our review of currently available educational software has shown that there is a critical need for technology enhanced, high-quality science materials for middle school students that not only are based upon

current research practice, but also have high production quality that would appeal to today's technology savvy students.

It is based upon this need that *Alien Rescue* was conceived in 1997 at the University of Texas at Austin. Presented on a CD, *Alien Rescue* is a problem-based hypermedia learning environment designed to engage 6th graders in scientific investigations aimed at finding solutions to complex and meaningful problems. It is developed in accordance with the National Science Education Standards and the Texas Essential Knowledge and Skills guidelines. While the primary learning objectives of *Alien Rescue* focus on astronomy and space travel, the program offers ties to other curriculum areas, including life science, math, and history. *Alien Rescue* recently received the First Prize in the 2001 Learning Software Design Competition sponsored by the University of Minnesota (http://design.umn.edu/LearningCompetition), and an honorable mention for ingenuity in the Best Educational Application category of Macromedia eLearning Innovation Award Program (4th quarter of 2001, http://www.macromedia.com/resources/elearning/eliap/winners/q4/).

In this paper, we will describe *Alien Rescue*, its theoretical underpinnings, the environment, the design features, the cognitive tools it offers, and its research agenda. As developers, we will share our reflection on the experience and how the next generation of educational software should be designed to maximize student interaction and active learning. Information on *Alien Rescue* can also be found on its web site at http://www.alienrescue.com/.

THEORETICAL UNDERPINNINGS

The design of *Alien Rescue* is guided by the theories and research on problem-based learning. Problem-based learning (PBL) is an instructional approach that exemplifies authentic learning and emphasizes solving problems in rich contexts. Though originally developed in

medical education (Barrows, 1996), it has been subsequently applied in a wide variety of professional schools including business, law, and education. In problem-based learning, students are given a problem replete with all the complexities typically found in real world situations, and work collaboratively to develop a solution. PBL provides students an opportunity to develop skills in problem definition and problem solving, to reflect on their own learning, and to develop a deep understanding of the content domain (Cognition and Technology Group at Vanderbilt, 1992; Jacobson & Spiro, 1995; Lajoie, 1993). Consequently, learning occurs as a direct result of students' efforts to define and solve the problem.

Three implementations of problem-based learning are of particular interest to *Alien Rescue*. Anchored instruction by the Cognition and Technology Group at Vanderbilt use video-based scenarios to anchor instruction in authentic problem-solving tasks (Cognition and Technology Group at Vanderbilt, 1992). Schank's goal-based scenarios use computer simulations to embed learning in problem-solving activities (Schank, Fano, Jona, & Bell, 1993). Cognitive flexibility theory by Rand Spiro emphasizes learning from multiple perspectives in ill-structured domains (Spiro & Jehng, 1990). Though approached in different ways, all three implementations deal with solving complex problems in authentic situations, emphasize the importance of student-centered activities, and use technology to deliver PBL.

Literature has demonstrated the potential of problem-based learning to enhance students' thinking skills (Boud & Feletti, 1991; Cognition and Technology Group at Vanderbilt, 1992; Stepien, Gallagher, & Workman, 1993). Gallagher, Stepien, and Rosenthal (1992) found that PBL let to an increase of the use of one problem-solving skill: problem finding. Problem finding involves exploring a situation fully to understand and define exactly what the problem is that needs to be solved. Stepien, Gallagher, and Workman (1993) found that students in PBL courses

changed from presenting arguments based most on emotions to ones based on supporting evidence and substantiated by reason. Williams (1993) reported on research from the medical field which showed that students who participated in a PBL curriculum had less difficulty in clinical rotation than students from a conventional curriculum, suggesting that PBL enhanced those students' ability to address real world problems.

However, research has also shown that the implementation of PBL in the classroom is a challenging and complex task both for teachers and students. Learning in a PBL environment is a challenge to the students because it requires their active participation in a self-directed manner. The development of a solution plan requires learners to sift through vast amounts of information, distinguishing what is pertinent from that which is not. Learners need to be able to generate and evaluate their problem-solving goals and organize their knowledge in ways that facilitate development of a solution. Much literature has focused on gifted and mature learners, for whom some even suggest that PBL is more suitable than the regular education students, as they possess more sophisticated learning strategies (Hmelo & Ferrari, 1997). Teaching in PBL is also a challenge because teachers must not only be familiar with the PBL approach and the skills needed to teach with it, but also be able to provide necessary and often "just-in-time" support tailored to individual and small group needs. Such challenges can be especially overwhelming in K-12 classrooms, where learners may have limited self-directed learning skills and classes may be large.

Effective implementation of PBL requires scaffolding (Koschmann, Kelson, Feltovich, & Barrows, 1996). One form of scaffolding can be realized by using computers as cognitive tools to support learners in their information processing and knowledge construction process. Cognitive tools are instruments that assist learners in accomplishing complex cognitive tasks

(Lajoie, 1993). They are tools to "enhance the cognitive powers of learners during thinking, problem-solving, and learning" (Jonassen & Reeves, 1996, p. 693). Lajoie (1993) identified four types of cognitive tools according to the functions they serve: Tools that (1) support cognitive and metacognitive processes; (2) share the cognitive load by providing support for lower level cognitive skills so that resources are left for higher order thinking skills; (3) allow learners to engage in cognitive activities that would be out of their reach otherwise; and (4) allow learners to generate and test hypotheses in the context of problem solving. These four types are not mutually exclusive.

Literature has shown that the use of cognitive tools has the potential to enhance student learning. Harper, Hedberg, Corderoy, and Wright (2000) described a multimedia learning environment, *Exploring the Nardoo*, in which cognitive tools are provided to assist students in making the transition from novice to expert. High school students used tools such as a personal digital assistant, nine genre templates, and three simulators for problem-solving, communicating, and preparing multimedia reports while studying ecology. Lajoie (1993) discussed research using *Bio-World,* a program that supports scientific reasoning about diseases. In *Bio-World*, the argumentation process is enhanced by tools that allow students to form diagnostic hypotheses and collect evidence to confirm or disconfirm their diagnoses. Results from a pilot study showed that high school students' confidence level increased as they used the program, and there was a significant difference in confidence ratings between the first and the last diagnosis that students entered. Greer, McCalla, Cooke, Collins, Kumar, Bishop, and Vassileva (2000) presented two intelligent peer help systems as cognitive tools in a cooperative learning environment: Cooperative Peer Response System and Peer Help System. Together, they provide a cooperative knowledge construction environment where students are able to explore the information,

elaborate and explain their interpretation of the knowledge, compare their knowledge with that of the others', and evaluate their own knowledge, all as they are engaged in online communications.

In *Alien Rescue*, problem-based learning is supported through a set of cognitive tools developed using hypermedia technology. With its nonlinear, associative, interactive, and multimedia capabilities, hypermedia offers rich resources to present PBL in an authentic context and support students' learning as they are engaged in complex and self-directed cognitive activities. In the research and development of *Alien Rescue*, it is our intention to investigate and understand in what ways hypermedia technology can be used as cognitive tools to share the responsibilities of teachers to provide necessary scaffolding to support learning in a PBL environment for students at all levels.

THE *ALIEN RESCUE* ENVIRONMENT

Program Description

> "I'm speaking in front of the U.N. building in New York, where it appears that the unimaginable has happened. An alien spaceship has entered an orbit around the Earth…."

The science fiction premise of *Alien Rescue* takes students to a newly operational international space station where they become a part of a worldwide effort to rescue alien life forms. Students are informed that a group of six species of aliens, fleeing their own planetary system, have arrived in Earth orbit. Their ship was damaged during their voyage. Except for their engines and computer databases, little of their technology continues to function. To survive, they must find new homes on worlds that can support their life forms. Having picked up Earth broadcasts, the aliens learned our languages with the intention of asking for our help to relocate to worlds in our solar system. However, when their life support failed completely, the aliens could only send out a distress message. They then entered a state of suspended animation, where they must remain until they are safely relocated to suitable worlds.

Students, acting as scientists, are asked to participate in this rescue operation, and their task is to determine the most suitable relocation site for each alien species. To solve this problem, students must engage in a variety of activities. They must learn about the aliens and identify the basic needs of each species. They must then investigate the planets and moons of our solar system, searching them for possible matches with the needs of the aliens. Students gather this information by performing searches in the databases and launching probes that they have constructed to gather the additional information not available through the existing databases. They must also engage in collaborative planning and decision-making as they determine how to use the resources of the solar system effectively.

In the course of developing a solution plan, students learn about both our solar system and the tools and procedures scientists use to gather that information. The hypermedia program allows students to have access to all the tools and information needed to develop a solution plan, but the program is structured in such a way as to not suggest what that solution should be. Students are encouraged to explore the virtual space station as they determine for themselves the information they need and the process they will use to develop a solution plan. The use of *Alien Rescue* takes approximately fifteen 45-minute class sessions.

Design Features and Cognitive Tools

Alien Rescue incorporates design features that are supported by problem-based learning and hypermedia research. These features include:

(1) situating the problem in a rich context and allowing learners to engage in scientific inquiries as experts do;

(2) presenting the problem with its complexity, yet providing tools to support students in working with the complexity;

(3) providing information in multimedia formats to allow dynamic and interactive presentations that address different learning styles and student needs;

(4) providing experts' guidance from multiple perspectives to facilitate knowledge acquisition and transfer; and

(5) emphasizing the interrelated nature of knowledge through hypermedia nodes and links; and providing connections to other curriculum areas such as mathematics, biology, social studies, history, reading, and writing.

A set of cognitive tools is provided to scaffold students' problem-solving process. These tools are available through a two-layered interface in *Alien Rescue*: (1) the international space station with five rooms, each containing an instrument students can use to gather information and (2) the imaginary goggles students are wearing wherever they go in the environment. Using Lajoie's categorization (1993), these tools can be grouped into: (1) Tools that share the cognitive load, (2) tools that support cognitive processes, (3) tools that support cognitive activities that would be out of reach otherwise, and (4) tools that allow hypotheses generation and testing. Table 1 lists each tool and its function. Using the tools in categories 1 and 2, students locate helpful resources, search and research existing knowledge databases, select relevant information, and make effective decisions. With the tools in categories 3 and 4, students collect new data, interpret and organize data, build the rationale for their decisions and present their solution plan. Expert modeling and coaching for problem generation and problem solving is provided, in the form of video, by experts demonstrating how to use the tools, thinking aloud as they engage in using those tools to develop a solution for one of the species, and sharing stories about how scientists have used these tools in the past to gather information about the worlds in our solar system. The scripts for such video clips were developed by examining how students used an

earlier version of the program without modeling, noting their sources of difficulty, then providing modeling to support them. It is important to note that each cognitive tool is included for a purpose and has its role in the assistance of the problem-solving process. *Alien Rescue* is also rich in its use of multimedia. All media (i.e. text, graphics, audio, video, 3D images, animation) are incorporated in various aspects of the program. The use of visual media has greatly enhanced the content presentation of the program. Some screen shots are presented in Figure 1.

Insert Table 1 here

Insert Figure 1 here

THE DEVELOPMENT

The development of *Alien Rescue* follows a model based upon the practice in the multimedia industry and current literature in instructional technology. This model has four phases: (1) planning, (2) designing, (3) production, and (4) evaluation (Liu, Jones, & Hemstreet, 1998). Testing and revision is an on-going process both from the teachers and the students. The production of *Alien Rescue* uses state-of-art multimedia tools including *Macromedia Director, Adobe Photoshop, Adobe Premiere, Adobe Illustrator, Apple QTVR and QuickTime, Bryce 3D, Strata Studio Pro, Painter, Debabilizer, 3D Studio Max, Media Cleaner Pro, SoundEdit 16, Sound Forge,* and *Organica*. Except for the copyright-free images of worlds in our solar system

available from NASA, all elements in *Alien Rescue* are original and created using a combination of these tools.

A noteworthy feature of *Alien Rescue* is that the majority of the *Alien Rescue* development team consisted of graduate and undergraduate students majoring in different fields at the University of Texas at Austin, and harnessing their diverse talents and ideas was a major characteristic of the design process. The first month of development began with a passionate discussion by this team of what cognitive support and resources are needed for sixth graders to solve an ill-structured problem, and such discussions continued throughout the process as new design issues arose. The production has drawn expertise from such fields as instructional design, hypermedia research, astronomy, graphic design, multimedia programming, video, and audio. It was primarily developed through assistantships, fellowships, independent studies, course work, small grants, and lots of dedicated volunteer hours from a group with a variety of talents. It was also driven by students' work on their dissertations and master's reports. Despite the challenge of much institutional coming and going, *Alien Rescue* offered faculty and students an opportunity to conceive an idea grounded in current research, test it, revise it, and implement it in a real-world setting. More importantly, it provided an excellent opportunity for students to develop their skills as multimedia designers and developers and as educational researchers. Such an experience not only enriched students' learning, but also helped them better prepare for their future careers.

FIELD-TESTING AND RESEARCH AGENDA

Alien Rescue's design is informed by the current research practice on problem-based learning and hypermedia. We also learned much from evaluating current educational software and seeing their uses in the classrooms (Williams, Pedersen, & Liu, 1998). Field-testing and research are integral parts of *Alien Rescue* development. Apart from many iterative formal and

informal evaluations, studies have been conducted to explore effective ways to accomplish the program goals and to determine how certain cognitive tools should be constructed.

An important goal for *Alien Rescue* is to provide an environment for real-life problem-solving. *Alien Rescue* engages students in developing a solution to an ill-structured problem. Ill-structured problems are complex, lack clear definition, and require extended research and the consideration of multiple solution plans. Typically, the problems confronting both people in their everyday lives and scientists engaged in their professional activities are ill-structured in nature. As students work with *Alien Rescue,* they deal with the same types of complications and constraints that characterize problem solving in the real world. Research was conducted to investigate if providing expert stories on how scientists solve problems would have an impact on students' achievement, problem solving, and attitude when working in *Alien Rescue* (Williams, 1999). Two versions of *Alien Rescue* were constructed: stories and non-stories. No significant differences were found on measures of factual knowledge recall, attitude toward science, or attitude toward *Alien Rescue* learning environment. However, when asked to solve near transfer and far transfer problems, students in the story treatment did significantly better than students in the non-story condition. This finding suggests that expert stories can scaffold student learning. As a result, expert stories are a part of the *Alien Rescue* program.

Much of the learning that students do during *Alien Rescue* arises out of their pursuit of information they determine they need. This type of self-direction is critical to the development of the habits of life-long learning. One of the program goals is to support students' development of self-directed learning skills through the provision of expert modeling within the program. A study was performed to examine the effects of modeling expert cognitive strategies during *Alien Rescue* (Pedersen, 2000). Three treatment conditions were devised to isolate the effect of the

cognitive modeling. Results suggested that the cognitive modeling offered through the expert tool brought the way students worked during periods of self-directed study in *Alien Rescue* into line with expert actions. It impacted the quality of the rationales students wrote for their solutions to the central problem of the program and to a problem-solving task in an unrelated context. The expert modeling tool, therefore, became a part of *Alien Rescue*.

In addition to the findings from the above research, the results of extensive pilot-testing with about 1400 sixth graders helped to improve various aspects of the program. For example, an early copy and paste feature in the notebook was eliminated when we found students copying large blocks of text without considering their pertinence to the development of a solution. This led us in the design of the program to place greater emphasis on not facilitating activities that could prove cognitively counterproductive. Pilot testing also showed that the probe design room was the most popular feature of the program, and that some students would launch a large number of probes without considering design issues or the data these probes returned. We therefore included an authorization code in the Launch Room. In order to launch a probe, students need to get the code from their teacher, and in order to get the code from the teacher, students must be able to defend their designs and comment on their learning from previous probes. Designing a way to capitalize on students' interest in the probe design process to promote their reflection and articulation of their reasoning was a result of our observations of the target audience in the target setting.

Initial feedback from the teachers and the students was enthusiastic. Tables 2 and 3 list a few comments from the students and teachers on *Alien Rescue*.

Insert Table 2 here

Insert Table 3 here

At this point, *Alien Rescue* (version 2) has just been completed. It will be used in a number of middle schools in the coming year. Research on using *Alien Rescue* has just begun. Present and future research planned includes investigation on such issues as:

- the use of hypermedia cognitive tools to support problem-solving
- students' navigation patterns during *Alien Rescue* use
- collaborative learning as supported through *Alien Rescue*
- how students with different abilities perform in this environment
- students' attitudes toward the *Alien Rescue* environment and science learning
- teachers' perspective toward and their role in a PBL environment like *Alien Rescue*.

OUR REFLECTION

Encouraging students to be active learners and develop problem-solving skills are important educational goals. Supporting such goals with hypermedia-based cognitive tools is what *Alien Rescue* aims for. We have learned much from the experience of creating and implementing this hypermedia-supported problem-based learning environment. A few factors that we think are critically important to ensure a success of a product include:

- The design of a product must be grounded in current educational theories and research practice. Research must not only inform the product design, but also become an integral part of its development.

• Field-testing by the audience should be an inherent and ongoing process. Results from the evaluation should be incorporated into the product improvement in a timely manner.

• Cognitive tools included in the product must be built with a specific purpose to support the overall learning process. That it, they are built into the product because there is evidence that they can assist learning and students will use them.

• The product should utilize state-of-art technologies and have high production quality in order to present a learning environment that will appeal to today's MTV generation.

• Developing a high quality hypermedia product is a complicated task. A team of people with various talents is needed. Project management is a key in ensuring the continuity and quality of the product.

Creating a complex hypermedia product in a university setting with limited funding is a very challenging and rewarding experience. The overwhelming positive feedback from students and teachers provides a constant source of encouragement. The learning experience we have gained, as developers and researchers in producing *Alien Rescue*, have deepened our understanding of how to design student-centered learning environments with hypermedia technology. From what we have learned, we believe that hypermedia supported cognitive tools, if designed effectively, can support students' active learning and enhance their problem-solving skills.

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REFERENCES

Barrows, H. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning, 68*, 3-12.

Boud, D., & Feletti, G. (1991). *The challenge of problem based learning*. London: Kogan Page.

Cognition and Technology Group at Vanderbilt. (1992). The Jasper series as an example of anchored instruction: Theory, program description, and assessment data. *Educational Psychologist*, 27(3), 291-315.

Gallagher, S. A., Stepien, W. J., & Rosenthal, H. (1992). The effects of problem-based learning on problem solving. *Gifted Child Quarterly, 36*(4), 195-200.

Greer, J., Mccalla, G., Cooke, J., Collins, J., Kumar, V., Bishop, A., & Vassileva, J. (2000). Integrating cognitive tools for peer help: The intelligent intranet peer help-desk project. In P. S. Lajoie (Ed), *Computer as cognitive tools, volume two: No more walls.* (pp. 69-95). Mahwah, NJ: Lawrence Erlbaum.Associates, Inc.

Harper, B., Hedberg, J., Corderoy, B., & Wright, R. (2000). Employing cognitive tools within interactive multimedia applications. In P. S. Lajoie (Ed), *Computer as cognitive tools, volume two: No more walls.* (pp. 227-246). Mahwah, NJ: Lawrence Erlbaum.Associates, Inc.

Hmelo, C. E., & Ferrari, M. (1997). The problem-based learning tutorial: Cultivating higher order thinking skills. *Journal for the Education of the Gifted*, *20*(4), 401-422.

Jacobson, M. & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, *12*(4), 301-333.

Jonassen D. H. (1996). *Computers in the classroom: Mindtools for critical thinking*. Columbus. OH: Prentice Hall.

Jonassen D. H., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 693-719). NY: Macmillan.

Lajoie, S. P. (1993). Computer environments as cognitive tools for enhancing learning. In S. P. Lajoie and S. J. Derry (Eds.), *Computers as Cognitive Tools* (pp.261-288). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Koschmann, T., Kelson, A. C., Feltovich, P. J., & Barrows, H. S. (1996). Computer-supported problem-based learning: A principled approach to the use of computers in collaborative learning. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 83-124). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Liu, M, Jones, C., & Hemstreet, S. (1998). A study of the multimedia design and production process by the practitioners. *Journal of Research on Computing in Education, 30*(3), 254-280.

National Science Board (1999). *Preparing Our Children: Math and Science Education in the National Interest*. Retrieved November 10, 1999 from the World Wide Web: http://www.nsf.gov/pubs/1999/nsb9931/start.htm

Pedersen, S. (2000). *Cognitive Modeling During Problem-Based Learning: The Effects of a Hypermedia Expert Tool.* Unpublished doctoral Dissertation, University of Texas at Austin, Austin, TX.

Schank, R., Fano, A., Jona, M., & Bell, B. (1993). *The design of goal-based scenarios* (Tech. Rep. No. 39). Evanston, IL: Northwestern University, The Institute for the Learning Sciences.

Spiro, R. J., & Jehng, J. (1990). Cognitive flexibility theory: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In D. Nix & R. Spiro (Eds.), *Cognition, Education, and Multimedia* (pp.163-205). Hillsdale, NJ: Lawrence Erlbaum Associates.

Stepien, W. J., Gallagher, S. A., & Workman, D. (1993). Problem-based learning for traditional and interdisciplinary classrooms. *Journal for the Education of the Gifted, 16*(4), 338-357.

Williams, D, Pedersen, S., & Liu, M. (1998). An evaluation of the use of problem-based learning software by middle school students. *Journal for Universal Computer Science* [Special Issue], *4*(4), 466-483.

Williams. D. C. (1999). *Hypermedia-supported Authentic Learning Environments (HALE): Examination of Tools and Features Which can Support Students Learning*. Unpublished doctoral Dissertation, University of Texas at Austin, Austin, TX.

Williams, S. M. (1993). Putting case based learning into context: Examples from legal, business, and medical education. *Journal of the Learning Sciences, 2*, 367-427.

Table 1. Hypermedia-Supported Cognitive tools in *Alien Rescue*

Tool Category	Tool Name	Tool Function
(1) Tools sharing cognitive overload	Conference Room	Students receive video messages from Earth in the conference room. These messages provide details about the problem situation and help direct student activity. These messages help to maintain the impression that students are part of a scientific community, where coordinated efforts and frequent communication are essential components of problem solving.
	Research Lab	It houses the Alien computer. Because the alien ship is damaged, scientists decide to move the alien computer to the space station. It contains information about the aliens: their physiology, technology, homeworlds, and history. Students must sift through the information to identify the needs of each alien species.
	Charts	A spectrogram chart and a periodic table are provided for students to use in analyzing data they collect.
	Solar System Database	This contains information about our sun, the nine planets, and ten of the moons in our solar system. Information useful to solving the problem is provided, but the database is structured in such a way as not to suggest which pieces of information are relevant to the problem or what the best solution to the problem might be. The database includes pictures that students can bookmark for later retrieval.
	Concepts Database	A few of the key science concepts useful to solving the problem are presented in the concepts database
	Messages	Periodically through the program, students receive video email. These messages are recorded in text form in the message tool for students to review as they deem necessary.
	Mission Database	Students can review information on five landmark probe missions to see how scientists designed probes to collect specific types of data in the past.
(2) Tools supporting cognitive process	Notebook	Students use their notebook to collect and organize information useful in solving the problem. Students can create numerous sections within their notebook to help them organize their notes. The notebook was deliberately designed not to allow students to cut and paste information contained in the rest of the program, meaning that students must type their own notes based on what they think is important enough to record. A second function of the notebook is the bookmarks feature. Students can drag pictures and video from any part of the program to their notebook. These media elements are bookmarked for later review and possible use in presentations.
	Expert Modeling Tool	This tool looks like an icon of a person's head. It contains videos in which expert scientists explain how they would address aspects of the problem and share stories about their experiences. The expert tool is context sensitive, meaning that it only appears

		when the expert has information to share about the tool students are currently using. Students can use this tool when they feel stuck and uncertain of how to proceed.
(3) Tools supporting activities that otherwise would not possible	Probe Design Room	The Probe Design Room contains lists and descriptions of real scientific equipment used in both past and future probe missions to investigate other worlds in our solar system. Students construct probes by making choices within four categories: probe type, communication, power source, and instruments. Budgetary constraints force students to consider their choices carefully and make compromises.
	Launch Room	Students review the probes they have built in the Probe Builder, and decide which ones to actually send in the Launch Room. Only probes that are launched show up in the Control Room, where data from them is displayed.
(4) Tools supporting hypothesis testing	Control Room	Raw data collected by the probes are displayed in the Control Room. Students must interpret this data in order to turn it into information that they can use to develop their solution. As in all probe missions, malfunctions are possible, and poor planning can result in mission failure.
	Probe Deign Room	Same as above
	Solution Form	A form showing up after students have used the program for 2/3 of the time, to provide a structure for them to submit their recommendations and rationales for each of the species.
	Presentation Possibility	A typical assignment for students to be given within *Alien Rescue* is to create a presentation on a decision they made and their rationale for that decision. The images bookmarked in the Notebook tool can be exported for use in Powerpoint presentation if the teachers choose to do so.

Table 2. Sample Students' Feedback on *Alien Rescue*

Comments From the Students
· It was really cool because you are getting a chance to get on the computer and find information about stuff and getting to learn more about planets and more about the species. When I say it is cool, I mean that it was interesting because it made us think a lot and sometimes when we are doing assignments we don't really have to think. This was challenging and it was fun and I just really enjoyed it.
· I would probably give it a ten (on a scale of 1-10) because it helps you learn a lot of things because you learn to take notes, which is really important. You learn to find words and to be more independent because you have to find out where to go on your own because there is not help or whatever. And it's also really fun to research and send up probes and stuff.
· We felt that we worked in the same way that scientists do.
· It is a very good project because usually I think science is boring, and then after this, I am interested in the solar system. It was fun to do it on the computer instead of doing it with a book.
· We felt that we had more control over what we were doing than we normally do in school.
· It was more fun to solve the problems by yourself than following the instructions from the teacher.
· You can't just pick a planet at random. You have to find all the facts, you have to write them down, to compare, tell what they need, what they don't need, what we have actually in our own atmospheres.
· It's more interactive, because you have to hypothesize and gather information. You had to use like the scientific method, really.

Table 3. Sample Teachers' Feedback on *Alien Rescue*

Comments From the Teachers

- I think it’s a great way to teach collaboration. It has taught them problem solving skills. They had to rely on each other for the research that they did and for the information that each one had gathered. They had to pool their information to come up with a solution.

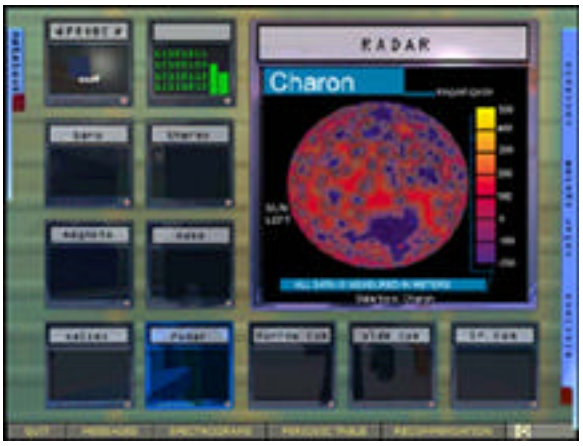
- Since school started, he was totally disengaged from the classroom. He has not been turning in work, not listening, in class, playing with things, totally disorganized. And when we started Alien Rescue on Monday. On Tuesday, he came to me in class and he said, 'I like this.' He is totally absorbed by it and is doing a great job.

- I’ve used Alien Rescue with students six times now, and I’ve yet to see off-task behavior or careless work. Students cooperate with their peers. They take responsibility for their work, and they take pride in a job well done. In part I think this happens because students like the problem scenario and they love working on the computer, but I also think a huge motivator is the sense of control they have over their work. They can do what makes sense to them and no one tells them they are wrong or should do it another way.

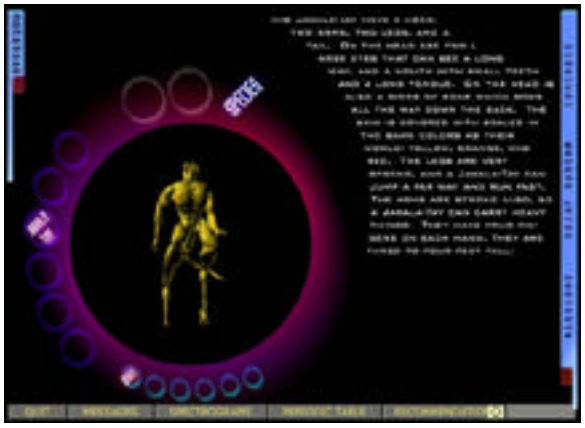
- I was so impressed with the instructional design of the program, as well as the computer design. It is a beautiful piece of work!

- Thank you so much for bringing this experience to our campus, I think it has done a great deal to bring a new awareness of some teaching techniques and some technology to our staff and our students.

Figure. 1 Screen Shots of *Alien Rescue* Environment

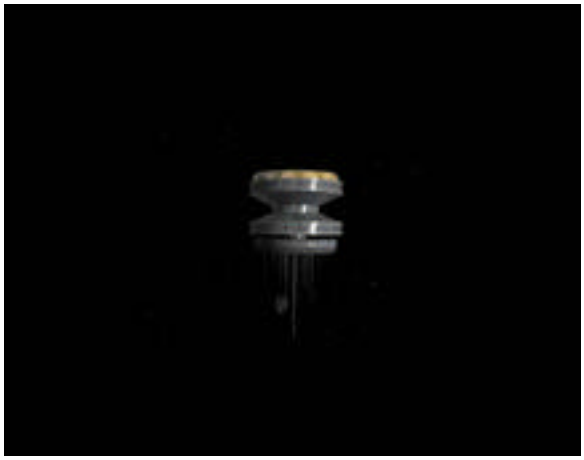


Control Room



Research Lab: Alien Database

Probe Design Room



The Space Station

Expert Tool, Notebook, and Solar System Database

Conference Room