

# TRAILS Y2 Annual Report, September 2003 – August 2004

## Introduction

TRAILS aims to broaden and support the pool of talent available to create powerful technology for K-12 education, such as simulations, adaptive tutorials, interactive exhibits, and educational games. Our approach focuses on engaging teams of university students in the creation of educational technology through project-based design courses. Through these courses TRAILS intends to have three major effects: to better prepare tomorrow's designers of educational tools, to better prepare the teachers who will use such tools, and—by publishing select course projects— to generate new tools for K-12 education.

TRAILS-affiliated courses are founded on a common set of principles, bringing together students from computer science, information science, education, and the arts to collaborate on the design of educational tools. This interdisciplinary approach builds on the ESCOT project, which found that close teamwork between developers and teachers was an effective means of creating valuable educational software. TRAILS course teams are taught how to accurately assess educational requirements, design prototype tools, and field-test them in classrooms or other authentic educational settings.

With funding from the National Science Foundation, TRAILS was launched in 2002 at SRI International's Center for Technology in Learning. Stanford University and the University of Colorado at Boulder offered the first TRAILS-affiliated courses beginning in spring 2003. The Math Forum at Drexel University is publishing selected software created by TRAILS students and providing mentoring on pedagogical issues. Coordinating the network of TRAILS courses and other partners is SRI, which provides centralized tools for designing and prototyping educational software, and facilitates access to pedagogical and technical experts.

The project has finished its second year of the NSF grant. The activities this past year can be organized into three general categories, University Education, Collaborative Software Design, Classroom Impact, and Other Activities.

## Activities:

*What have been your major research and education activities (experiments, observations, simulations, presentations, etc.)?*

The highlight of Year 2 was the offering of 2 updated TRAILS-affiliated courses at Stanford University and University of Colorado at Boulder. These courses benefited from the experience of running the experimental TRAILS-affiliated courses earlier in Year 1 at the same two universities. Both sites used a more structured syllabus, more education-oriented readings, and more built-in opportunities for testing in K-12 classrooms.

Experience from Year 1 also informed new strategies for designing online tools to scaffold student learning and providing guidance for students and instructors. The TRAILS team

developed a Web application called the “Gallery of Reusable Projects” (the acronym, GORP, is a wordplay on trail food). GORP is an online tool enabling students and instructors to collect, categorize, describe, and evaluate educational tools. For precision’s sake, we are calling these tools interactive “curriculets” rather than “applets” to underscore the fact that a complete educational application needs to be packaged along with instructions, teacher notes, and linkages to educational standards in order to realize its full value. GORP scaffolds students’ learning by leading them through a step-by-step process where they consider the same questions a professional instructional designer would ask while reviewing an interactive tool.

The project also conducted a competition for selecting two university course sites to join the TRAILS network. Frank Lee, an assistant professor from Drexel University, and Chris Hoadley, an assistant professor from Pennsylvania State University, will begin teaching TRAILS courses in the 2004-2005 school year.

Below we list our major activities over the last year in Undergraduate Education, Collaborative Software Design, and Classroom Impact, followed by more details about our project planning and other activities.

### **University Education Activities**

- The University of Colorado Computer Science Department (CU-CS) offered an updated course "Game Design for Education". This was co-taught by Alex Repenning (returning from Year 1) and Dr. Clayton Lewis who has taught similar project-oriented software development courses and has new research interests in game technology. The course was held in a mixed teaching/working lab: Educational Discovery Lab; Coleman lab.
- CU-CS reviewed several books with respect to their suitability as textbook for the "Game Design for Education" course. In the end they chose to use selections from various texts and articles as described on the course Web site, <http://games4education.cs.Colorado.edu>
- Stanford also offered an update course, this year following a more presentation-oriented model in which students in the course presented weekly, sharing their progress and calling on classmates for responses and input. Stanford also revised the TRAILS 2003 curriculum to:
  - Include the use of GORP (Gallery of Reusable Products).
  - Include more learning and education focused readings and more emphasis on the integration of curriculum and technology.
  - Include more class activities relating to discussion and synthesis of readings.
  - Include more instruction on collaboration process, though fewer team building activities. (For example, RAs presented key findings from collaboration research from the previous year, which provided a foundation for improved collaborative processes.)
  - Add reading responses and continued to require journal responses.
  - Include concurrent design of curriculum materials with technology development was emphasized.

- Include materials provided by the Math Forum for helping students evaluate educational applets and understand possible function, capabilities, and effectiveness and shortcomings.
- Stanford initially used an educational software rubric in its course activities that was developed by Underwood et al as part of a seed grant from the Center for Innovative Learning Technologies (CILT). Later, the course transitioned to a more refined and customized rubric (see description of GORP below) to guide student projects and evaluate them.
- Stanford continued to recruit partners to work with groups on their projects and provide opportunities for their project field tests. This year, partners came from the Stanford Teacher Education Program pre-service students, in-service teachers, and museum educators. The three resulting Stanford student projects were designed for a high school algebra class, The Tech Museum, and a 2nd grade science class.
- Stanford analyzed the field notes, student interviews and journals from the 2003 and 2004 Stanford TRAILS courses.
- SRI helped in planning courses being taught in Winter/Spring 2004 at Stanford and CU. Jennifer Knudsen from SRI stepped in to co-teach the Stanford course to cover for Shelley Goldman's sick leave.
- Course designs at both Stanford and CU were influenced by a key document, "Pithy Course Principles," that emerged from a meeting in the fall of 2003 (described below). This document outlines the essential processes and products that characterize a TRAILS course.
- CU-Comm conducted internal focus groups with members of the TRAILS team to debrief from Stanford and Colorado's spring courses. The results will be presented at our upcoming Summer Partners meeting.
- SRI conducted a competition to add new university course sites to the TRAILS network. They assembled a "short list" of likely candidates for teaching a TRAILS course then interviewed some candidates to understand the issues. They developed a formal application form and distributed a Request For Proposals.
- The Math Form developed an activity for the TRAILS courses called Twenty Questions (<http://mathforum.org/~salejan/trails/feedback.html>) that was designed to (a) provide descriptive information about students in the TRAILS class, (b) gather information about students' abilities to think about software, and (c) encourage students' to think about the potential of software to support learning. The Math Form worked closely with the CU TRAILS course to pilot the Twenty Questions Activity.
- The Math Forum also provided "guidance" for TRAILS courses in the form of responses, feedback, and questions for the students and attended project idea presentations and final project presentations in the CU course.

## Collaborative Software Design Activities

- CU-CS tested a large number of 2D/3D game and simulation authoring tools. They explored how to support of the collaborative design of games and how to ease their implementation.
- CU-CS reviewed and analyzed End-User Development ideas of AgentSheets and related systems. They collected End-User Development principles. They wrote book chapter for the upcoming book *End-User Development* published by Kluwer.
- CU-CS explored innovative interactions techniques to develop interactive educational materials including content (2D + 3D) and behaviors. They created technological interfaces to unconventional interface devices including GamePads and Joysticks. They created early prototypes of GamePad-controlled End-User Development techniques for 3D model creation. They tested the prototype with middle school children.
- CU-CS interviewed CU faculty using Blackboard tool for collaborative teaching styles. They tried to find faculty members using WebCT in computer science, without success. They explored informal collaboration support technologies including Macromedia Contribute and WebDAV, and reviewed several books for suitability as a textbook for the "Game Design for Education" course.
- As an alternative to Blackboard, CU-CS developed WebDAV-based framework to collect, organize and share project-oriented work for the CU course. This framework can be seen as a prototype End-User Development tool that turns informal file spaces (folder/file hierarchies) into formal information spaces (html).
- CU-CS created early prototypes of workflow tools integrated into design + implementation tools by scripting existing communication/collaboration tools including chat (iChat), shared calendar (iCal), email (Apple Mail, Eudora), and chat rooms.
- Stanford also explored the use of Blackboard, and—unlike CU—decided it could be appropriate for their course. Blackboard allowed instructors to post course information, documents, and announcements. It also allowed students to post their work and communicate. Because it is a repository for student work, it also served the purpose of allowing the research team to follow the progress of the class.
- SRI applied meta-architecture approaches to identify opportunities for centralized tools to support collaborative software design. They developed paper-prototypes of some of the most promising ideas and finally settled on the concept of "GORP" (Gallery Of Reusable Projects). They built GORP into working code, and demonstrated alpha versions of it to teachers and students at Stanford and Colorado. They deployed GORP in the CU course and used student feedback to guide several iterations of the design, including a wizard interface for faster entry of new curriculets.
- SRI identified key aspects of curriculets to track in GORP based on ESCOT experience about often-overlooked aspects of learning system design, a review of "backwards" curriculum design (Wiggins & McTighe), and needs expressed by TRAILS instructors at the University of Colorado and at Stanford.

- The team populated GORP with exemplary curricula and content from TRAILS-affiliated courses. SRI collected exemplary interactive curricula from ESCOT, Utah State, Interactivate and Merlot.
- SRI arranged for GORP to be used to catalog final projects in CU course. They created a custom "Game" tab for use in this and future educational game-oriented courses.
- CU-Comm reviewed literature on interdisciplinary design and projects similar to TRAILS in terms of goals of supporting students to work in interdisciplinary design teams. This has resulted in a detailed proposal for a major new addition to our public Web site, focused on supporting group work in TRAILS courses.

### **Classroom Impact Activities**

- As a way to understand the process of writing effective problem solving prompts for interactive curricula, the Math Form organized a 3-week session with a researcher and classroom teachers where they reviewed the structure of ESCOT Problems of the Week.
- The Math Form selected 5 of the 9 CU projects as showing potential for cataloging in Math Tools and/or the Math Forum site. Similarly, the Math Forum plans to link all three final projects from Stanford in Math Tools or elsewhere on the Math Forum site.
- The team developed a plan for brokering authentic projects between *publishers* who need content such as the Math Forum and the TRAILS *students* who have ideas for interactive curricula. TRAILS spring courses showed that TRAILS students can indeed create products at the level of quality found at on-line sites such as the Math Forum, Merlot, and TADRIOLA. SRI began to investigate how students could actually publish their work on such sites. SRI is exploring the role of broker where it could host book fair-like events that could occur early in the semester/quarter that helps match student projects with potential publishers. Publishers could be required to provide an editor who develops a relationship with a team or two. This Editor could be what becomes of the TRAILS Guide concept. Under this proposal the Editor would have a clearer role than a Guide, in that they are working to ensure that the product meets the basic requirements of the publisher. This publishing model proposal will be piloted in the fall in the new course at Drexel University.

### **Project Planning Activities**

- The team held a TRAILS Summer Partner's meeting to develop plans for Year 2, which generated a calendar of planned milestones for SRI and subcontractors.
- The team held a research planning meeting in Boulder in September 2003, in which we agreed on a concise set of Course Principles that characterize our university course offerings, and identified specific research goals that would lead to publications by the project.
- The team held a Winter Partners Meeting where among other things we reviewed immediate plans for the Stanford and CU classes, agreed on strategies for observing these courses, began organizing the static resources for a revised Web site, discussed how to support groupwork, and reviewed research results and upcoming research goals.

- The team overhauled the TRAILS public Web site, clarifying our research goals, and course principles. Most importantly we added new resources for design courses including syllabi, activities, reading lists, and tools.
- SRI launched the Weekly TRAILS newsletter for the TRAILS team to track progress, make announcements, etc.
- SRI upgraded and reorganized the TRAILS team Wiki site to improve information sharing across partners and encourage the regular capture of our design history and general decision-making.
- SRI conducted a literature review of Learning Object Metadata and Learning Object Design. The goal was to determine how TRAILS can have a greater impact beyond its partner institutions by making it easy for outsiders to find TRAILS resources that could be reused in other courses, such as syllabi, course activities, and ideas for student projects (i.e. interactive curricula.)

### **Other Activities**

- SRI attended the “Innovation and Technology in Computer Science Education” conference, 30 June – 2 July in Thessaloniki, Greece. They presented a poster about TRAILS and met with Manolis Koutlis, formerly of E-Slate, to discuss software development and deployment issues in education.
- SRI jointly organized an EdTech ITR PI’s meeting 16-18 July in Boulder, Colorado. This workshop focused on the areas of software engineering, training programs, and implementation of learning technologies as they relate to the professional preparation of learning technology specialists. The workshop resulted in a report to NSF’s EIA that included specific recommendations. A public report from this and its companion workshop from 2002 will be released in Spring 2004.
- SRI met with Larry Leifer and his colleagues at the Center for Design Research at Stanford to learn about their design courses and electronic design notebooks.
- SRI extended its literature review (available on-line from the team Wiki) to cover computer science education, design education, design notebooks, and new material on collaborative learning.
- SRI presented a poster about TRAILS at NSF’s Engineering & Computing Education Grantee Meeting 2003. Although "education" was in the title of the PI's meeting, the emphasis was almost exclusively higher-ed. Most projects related to engineering education and a few were targeted at computer science. Grants tended to be small in scale, exploring new kinds of student laboratories, curricula, educational tools, etc. Much of the discussion sessions were devoted to the politics of reforming higher-ed.
- CU-CS was invited to give several talks:
  - A keynote presentation to funding officers of the European Research Commission and the German Science Foundation: International Symposium on End User Development, Schloss Birlinghoven, Sankt Augustin (Bonn), Germany, October 7-8, 2003.
  - The Coleman Institute for Cognitive Disabilities Conference, “Technology, Neuroscience and the Future of Cognitive Disability”, Denver, Colorado, October 10, 2003.

- Media X Gaming to Learn workshop at Stanford University, September 18-19, 2003.
- Interact 2003, International Conference on Human-Computer Interaction, September 1-5, 2003 - Zürich, Switzerland.
- The Math Form and SRI presented related ESCOT work at the National Council of Teachers of Mathematics. The session was entitled *Collaboration as a Foundations for the Design and Usage of Technology Rich Problems*.
- CU-Comm attended the 2004 ACM SIG Computer Science Education conference and presented two papers on collaboration among computer science students. Most sessions this year focused on techniques for teaching programming and were not directly relevant to TRAILS. However, some papers of general relevance to TRAILS discussed working with users, and teaching the capstone course. CU-Comm reported on results of their study of students in computer science courses, including how several aspects of the culture of Computer Science as perceived by the students and as practiced in Engineering education work against efforts to encourage collaborative work. The second paper described an initial implementation of a tool that uses the strategy of structuring the resources available to students as a means of making collaborative work rational with respect to task accomplishment. Both papers are online at <http://www.cs.colorado.edu/~pltools/>

### **Looking forward to the last few months of year 2 and beyond. . .**

- The team will meet for the 2004 TRAILS Summer Partners event and make plans for the 2004-2005 school year with our expanded set of course sites. New research directions will be plotted, emphasizing data collection and publications for the last 2 years of the project.
- CU-CS will submit a paper for publication about theory of End-User Development, system built and early class room experience (Summer 2004).
- CU-CS will teach the Games 4 Education course again. CU will explore a two-semester version of this course.
- CU-CS, CU-Comm, Stanford, and the Math Forum will work with the new TRAILS partners Frank Lee (Drexel) and Chris Hoadley (PSU) to help them with their versions of TRAILS courses.
- CU-CS will explore collaboration with High-School level computer science course interested in using game design and implementation. This notion is partially inspired by another NSF project, "Computer Science Resources for Memphis Area High Schools" (NSF Award Abstract - #0338324).
- Stanford will collect and analyze data from its most recent TRAILS course and compare to its previous offering.
- The Math Form will develop an assessment instrument to measure growth in TRAILS students' abilities to include meaningful educational concepts in their projects. This will leverage lessons learned from the Twenty Questions Activity described earlier, and will be designed to work as a survey to be conducted at the very beginning and end of a TRAILS course.

- The Math Form will develop a consensus profile of what makes good educational software (what's needed for good design and development) and also what makes a good educational software developer.
- The Math Form will continue to find ways to “guide” within the established TRAILS courses. As pedagogical guiding develops, collect resources and train other content/pedagogical guides to support increased needs (scaling).
- The Math Form will develop relationships with digital libraries focusing on other content areas for the purpose of publishing student projects.
- CU-Comm will expand focus group debriefings for additional TRAILS courses.
- CU-Comm will present TRAILS to the Language-Action-Perspective Conference, in June 2004.
- CU-Comm will extract from previously collected data further models of collaboration in educational technology design groups. They will also work with others partners in planning new resources for group interaction to be incorporated into the TRAILS resource network.

## Findings:

*What are your major findings from the activities identified above?*

There was evidence that the changes to the Stanford and CU courses improved our course offerings in significant ways. There was definitely more of an emphasis on the educational component of CU’s class as compared to last year. Stanford found that explicitly emphasizing integration of curriculum with technology throughout course helps students create a fully integrated final product. Both courses remain models of two distinctive approaches to integrating a TRAILS perspective

After evaluation of the two experimental TRAILS courses in its first year, we concluded that university instructors need flexible instructional tools that can be adapted for their local contexts. After experimenting with an existing, full-featured, content management system called “Tiki”, it became clear that many of its features, such as forums and document storage, were already supported at each individual institution by other products such as the Blackboard course management system. Therefore the TRAILS project identified a need to shift to more focused, more modestly-scoped tools that could be used in an ad hoc, improvisatory, emergent fashion. University instructors seek simple and flexible tools that do not force them to adopt a particular curricular sequence or philosophical orientation. If we are to provide centralized resources for a variety of TRAILS courses, we need to make sure instructors can readily adapt these for their local contexts. On the other hand, instructors expressed a need for a catalog of exemplary products and a place for students to organize their design plans, and this informed our decision to pursue GORP.

This year the team has also learned some important lessons about powerful activities that can be used in TRAILS classrooms. The Math Forum discovered ways to get students to discuss and reflect on the issues of creating software with educational value. Stanford and CU-Comm uncovered techniques for encouraging productive collaborations in design teams.

Below we list more details about our findings in University Education, Collaborative Software Design, and other areas such as Group Process and Teamwork.

### **University Education Activities**

- There was evidence that the changes to the Stanford and CU courses improved our course offerings in significant ways. At CU's final presentations students consistently highlighted the educational value of their products. There was definitely more of an emphasis on the educational component of CU's class as compared to last year. Stanford found that explicitly emphasizing integration of curriculum with technology throughout course helps students create a fully integrated final product. They also noted that education and learning focused readings are perhaps more important than design readings. Both courses remain models of two distinctive approaches to integrating a TRAILS perspective.
- The conference on Innovation and Technology in Computer Science Education that SRI attended in the summer of 2003 made it clear that many CS faculty members were interested in teaching hands-on software design courses. However, most were developing their course syllabi in an ad-hoc fashion and could have benefited from the kind of pedagogical guidance that TRAILS can offer.
- We have noticed that game-related courses are becoming extremely popular in computer science programs especially for undergraduate students. We see educational game courses as a way to leverage this enthusiasm and direct it towards the creation of educational software.
- CU found that a large percentage of CS students are extremely interested, motivated and eager to design and implement games. However, the traditional curricula do not prepare them well. Students are not used to working effectively in teams. Students had few or no previous opportunity to combine and apply several computer science topics.
- Although a course combining topics in technology, education, and games seemed like the right approach, CU found it is nearly impossible to provide coherent coverage of game and education topics in a single semester course. Suitable textbooks for teaching game design are only just emerging.
- Developing the Pithy Course Principles document (described earlier) was a powerful way to align teaching and research efforts across the project. In addition, the principles turned out to be a useful artifact for communicating our TRAILS concept to potential future partners.
- The process of selecting new courses for the 2004-2005 school year (described above) helped us better recognize instructors and course plans that aligned well with our course principles.
- Our initial notion of TRAILS Guides was to have remote pedagogical and technical experts be available for TRAILS students. Even with some tweaking of how we presented Guides in the second iteration of our courses at Stanford and CU, instructors found it difficult to integrate them in important ways in the course. Video conferencing did seem to help to develop some rapport with students. We noted that a design team is

best served by pedagogical guides who not only have considerable teaching experience in general, but who are experienced in the particular content area of the project. If the interaction with a pedagogical guide is part of a required (graded) activity, students are more likely to take advantage of it.

- The Math Forum learned from the Twenty Questions Activity that it created a situation for the students to discuss the issues of creating software with educational value as documented in their online class discussion and email exchanges with Suzanne Alejandre. Students' responses to questions asking them about context and real-world connections indicated a wide range of understanding.
- The Math Forum found that students can demonstrate awareness of what is required to write an effective interactive curriculum by stepping them through a process of reflection.
- The Math Forum also found that students were able to identify aspects of an applet (chosen from a pre-determined list) that would contribute to interactivity, but they demonstrated no indication that the context of the applet (e.g. the problem associated with the applet) could contribute to its interactivity. Student descriptions of their definition of interactivity ranges from: "saves time, easy to use, easy to adjust/change data" to "ability of the user to be presented with a situation, provide input, and receive feedback based on that input." Almost all groups (except 1) identified at least 3 areas of mathematics for which their applet could be useful. The topics chosen ranged in terms of subject area, specificity, and level of difficulty. For example, students listed "addition," "subtraction," "derivatives," and "convex hulls." They also listed, "geometry" and "linear equations." No topic, area, or category was listed with more frequency than another.
- The Math Forum noted that students demonstrated an ability to think about individual differences among potential users based on age-related developmental needs.
- In approximately half of the groups studied by the Math Forum, students found the reviewed applet "fun;" these groups appreciated the ability to play with shape and color. Those who did not find the applet fun suggested that the applet could be fun, if it were accompanied by goals or objectives. Two groups suggested that real-world connections or contexts would make the applet more fun.
- The Math Forum found that students typically focused on changes that could be made to the applet and not the context of the applet if intending to enhance its use for an older rather than a younger student. However, one group's response did suggest that the context of the applet could be adjusted. Another group suggested that the usefulness of changing the context or story to be make it more age-appropriate. Finally, another group's response suggested that directions provided to the child could be adjusted.
- The Math Forum noted that approximately half of the groups suggested that the applets might be used in the classroom. Three groups mentioned that applets could be used for purposes of demonstration; two groups suggested that the applets would be more appropriate for teachers because they wouldn't hold the interest of students. One group suggested the need for context in order to be useful in the classroom.

## Collaborative Software Design Activities

- Review of metadata standards led us to realize that most of the static and dynamic resources that are emerging from our project can be considered learning objects according to Wiley's definition (Wiley, 2000) of "any digital resource that can be reused to support learning". To share these resources with the larger education community, TRAILS should leverage on existing efforts to create searchable learning object repositories. TRAILS learning objects should be tagged with metadata and published to a repository that has an audience of potentially interested users. To make TRAILS resources available on a continuing basis with minimal overhead, TRAILS should investigate methods for easier metadata tagging and upload to the repository (e.g. harvesting).
- Although the field of learning objects has many ways to characterize content, we found no single term that suitably captured the TRAILS product (described in our Course Principles document). Instead, we invented the term "Interactive Curriculet" to describe an artifact that combines curricular materials and technology into a modestly scoped bundle. We are now promoting this term with other organizations such as Utah State and the Math Forum.
- We were surprised to learn that design notebook research has dissipated in the last 10 years. We surmise that researchers found significant challenges weaving technology supports into the complex design process. When we visited Larry Leifer's lab we noted that primary medium for capturing design history was a printed report, not a sophisticated dynamic representation.
- GORP represented SRI's first centralized tool created specifically for supporting and inspiring educational software design in TRAILS courses. University instructors generally found the GORP concept appealing and found a several ways to use it in the 2003-2004 school year. There was a clear need for a catalog of exemplary products and a place for students to reflect on their design experiences in a scaffolded fashion. It appears important for SRI to offer agile, lightweight group support tools that can be used in an emergent fashion by working design groups.
- For Stanford, the addition of GORP provided great scaffolding for students. Stanford students' initial effort to fill out the GORP highlighted where they were strong and where they needed to focus more attention. It also encouraged them to make some important choices about their projects earlier rather than later. It then became a reference tool along the way to check how they were aligning with their initial goals and where they were making changes. Finally, using the GORP as a reflection tool at the end of the project helped students see their progress, understand the complexity of the work and revisions that could be completed to improve their products.
- Finding the right data model for GORP proved challenging, given all the stakeholders we wanted to satisfy without bloating the model. Alignment with standards such as LOM also seemed like a good idea, but in practice we learned these were moving targets and rarely implemented fully.

- Although it seems like an obviously good idea to let people critique content in GORP, how to do this well is still an open question for us. Our work in developing rubrics for evaluating educational software helped us recognize the difficulty of the task. An interactive tool is rarely inherently flawed; it is the tool plus its context plus its supporting materials which determines its usefulness. TRAILS courses should consider highlighting the challenge of curriculum evaluation as part of students' learning experience.
- Existing authoring tools for games/simulation are either simple in which case they typically exclude real 3D support, or they do include 3D support but become very complex including a challenging learning curve and the mastery of several interacting tools. The middle ground between these two extremes is only very sparsely populated. We believe that a tool supporting a transition from simple to complex would be very efficient to support the design and implementation of educational content. The integration of design/implementation tools with communication/collaboration tools such as chat, email, and shared calendars could significantly reduce workflow overhead and, at the same time, serve as development management tools relevant for students and instructors.
- Unconventional human interface input devices such as GamePads have unique affordances that can help the authoring process by providing a mechanical means to fluidly vary the value of multiple variables simultaneously in ways that makes this suitable for the exploration of complex design spaces. This type of fluidity is not replicable with a conventional mouse-based interface. This kind of exploration could potentially be mapped onto conceptual, i.e., not just physical (e.g., as used in most games), dimensions of problem spaces that could be explored effectively by learners.
- End-User Design guidelines can be defined in ways independent of specific applications, languages and interfaces. We created a collection of End-User Design Guidelines at three levels: syntactic, semantic and pragmatic level.
- Online collaborative design tool still poses a challenge. Management of the tool is time consuming, and the repository function serves the research staff more directly than it serves the students.
- While student products are not fully tested or reliable, many of them qualify to be cataloged in digital libraries like Math Tools, the Math Forum's Internet Mathematics Library, or other sites for dissemination purposes as well as for receiving public feedback.

### **Other Findings (e.g., Group Process)**

- Metrics for group success are uncommon within research on group design.
- Students should be given the opportunity for introductions of group members, have agreement on project goals and importance, and do the work, but have some fun together in the process.
- Group management is helpful. Time conflicts must be addressed.
- Stanford found that successful cross-disciplinary collaboration is complex, but reflects some of what is known about collaborative problem solving
- Success on a TRAILS course may be multi-faceted, with different success levels for the final product, the team interactions and the learning experiences of group members.

- Prior experiences of collaboration influences group members' behavior.
- Stanford found that these factors lead to successful collaboration:
  - identification of common goals, develop a shared problem space
  - openness (lightheartedness, fun, trust)
  - commitment to the project, to members' roles and goals
  - balance of attention to both process and outcome.
- Few off-the-shelf group or teaming activities are task- or domain-specific to design.
- Computer science students remain largely committed to a task segmentation approach to group work (as opposed to the interaction and interdependence of collaboration).

## Training & Development:

*What research and teaching skills, and experience has the project helped provide to those who worked on the project?*

- Mike Chorost joined SRI's team on the TRAILS project in Fall 2003. He quickly came up to speed on the notion of interactive curriculets, and began integrating his experience as a university instructor and designer of collaboration tools.
- Jacob Dickerson provides Graduate Research Assistant support to CU-Comm on group process in the TRAILS project.
- Angela Booker was a teaching assistant for the Stanford course. She learned how to create a course syllabus, choose readings and construct assignments. Had teaching experience during the course.
- Angela Booker and Emma Mercier at Stanford engaged in interview and observational studies before, during and after the course. They began categorization of data and data analysis. Angela Booker and Emma Mercier collected & analyzed data from TRAILS courses. They gained experience construction and changing the curriculum and activities for the 2004 course. They also taught and gained advising experience. They collaborated to write a paper about the TRAILS class research and submitted it for presentation at the International Conference of the Learning Sciences.

## Outreach Activities

*What outreach activities have you undertaken to increase public understanding of, and participation in, science and technology?*

Below we list our major outreach activities

- CU-CS presented at the Coleman Conference which included the general public and members from the Cognitive Disabilities communities.
- The Math Forum provided improved versions of tools for Shodor Foundation workshop attendees (teachers, professors, researchers) taking place at multiple workshops (e.g., Super Computing 2003).
- SRI attended the Learning by Doing Conference in Sao Paulo, Brazil.

- CU-CS attended Educational Arcade workshop organized by MIT at E3 (Game conference).
- CU-CS presented at the 6th Annual International Symposium On Advanced Radio Technologies, "Wireless Technologies to Support People with Cognitive Disabilities on Public Transportation Systems", March 2-4, 2004, Boulder, CO.
- CU-CS organized several workshops at local middle school for students to build their own simulation and video game.
- Stanford continued to recruit Stanford Teacher Education Program students, in-service teachers, and educators in informal settings to work with course groups and provide opportunities for field tests of student-made TRAILS materials.

## Publications & Products

*Journal publications resulting from this work*

- DiGiano, C., Griffin, M., Huang, J., & Chung, M., (2003). Consolidating Ed-Tech Co-Design Best Practices through the TRAILS Project. The 8<sup>th</sup> Annual Conference on Innovation and Technology in Computer Science Education Proceedings, June 30-July 2, 2003, Thessaloniki, Greece.
- Ioannidou, A., Repenning, A., Lewis, C., Cherry, G., & Rader, C. (2003). Making Constructionism Work in the Classroom. *International Journal of Computers for Mathematical Learning*, 8(1), 63-108.  
download requires subscription for non-.edu addresses:  
<http://ipsapp007.kluweronline.com/content/getfile/4766/18/5/fulltext.pdf>
- Booker, A., Mercier, E. & Goldman, S. (2003). "We Know the Drill": The need to unlearn bad habits, become open, and attend in novel ways to new collaborations. Paper submitted to the International Conference of the Learning Sciences. June 2004.
- Repenning, A. and Ioannidou, A. Agent-Based End-User Development. *Communications of the ACM*. (in progress)
- Working Paper: Mercier, E. (in preparation). "What makes one group succeed where another fails? Evidence from two case studies." This paper compares the trajectories of two groups studied in the last two years
- NCTM 2004 presentation *Collaboration as a Foundation for the Design and Usage of Technology Rich Problems* - <http://mathforum.org/workshops/nctm2004/#0>
- NCTM 2004 presentation *Hands-on Introduction to Technology Tools that Help Your Students Learn Math* - <http://mathforum.org/workshops/nctm2004/#3>

## Books or other non-periodical, one-time publications resulting from this work

- Book chapter in progress: Repenning, A, and Ioannidou, A., What makes End-User Development Tick, Kluwer.

## Web site or other Internet site resulting from this work

- TRAILS GORP (Gallery of Reusable Projects) <http://trails-project.org/webapps/gorp/>
- Flash programming learning resources <<http://trails-project.org/resources/technical/flash/>>
- Web site for "Game Design for Education" course featuring the curriculum, homework, projects, references, schedules, and a discussion forum. <http://games4education.cs.colorado.edu/>
- TRAILS and The Math Forum - <http://mathforum.org/trails/>

## Other specific products (databases, physical collections, educational aids, software, instruments, or the like) resulting from this work

- None so far

## Contributions

TRAILS is already uncovering some important findings for the fields of computer science and education. We have also identified key services and resources needed to centrally and flexibly support multiple implementations of our course modules. We have identified challenges in getting students from different disciplines to work together effectively. We believe these findings are drawing out common issues in motivating and supporting teams of designers.

Ultimately, we see our TRAILS research as leading to new ways to train the next generation of educational technology developers and consumers, and to create exemplary digital content in the process. In the end, we anticipate our work will impact K-12 education by providing better technology and teachers who are better able to take advantage of it.

### 1. The principal discipline(s) of the project;

Courses such as the Games 4 Education course could bring back some of the energy and the enrollment in computer science. Nation wide computer science programs have experienced an enrollment drop between 20% and 50%. This could be a significant problem for IT training which to a large degree depends on Computer Science. Game oriented courses have the potential to serve as application course that not only motivate students but at the same time provide enormous learning potential because of their integrating nature.

For Communication Studies, this project is distinctive in its interdisciplinary collaboration with Computer Scientists, and for developing a model of collaboration that is relevant to design and development of technologies.

### 2. Other disciplines of science or engineering;

Education: game-based learning, on the one hand, is appealing because it capitalizes on the enormous energy that kids exhibit when playing video games, but, on the other hand, has not produced the kinds of results one would expect. The Games 4 Education course has provided some early steps in finding a good balance and conceptual frameworks in the design and implementation of educational games.

For Computer Science, this project is distinctive in its interdisciplinary collaboration with Communication, and for assessing the effectiveness of techniques for improving collaboration between students in technical and non-technical disciplines.

3. The development of human resources;

The course has already helped some of the student taking the course to get better jobs by exposing them to state of the art technologies including, for instance, Game AI.

We now have two computer science students who took the TRAILS course at Stanford who are planning to continue in careers related to educational software. Several of the education students are planning similar career moves.

4. The physical, institutional, or information resources that form the infrastructure for research and education;

The University of Colorado is beginning to explore a course model including the idea of application programming including game programming based on the positive response from students and faculty.

## **Participants**

*What people have worked on your project?*

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