

# TRAILS Y3 Annual Report, 1 September 2004 – 31 August 2005

## 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 selected course projects—to generate new tools for K-12 education.

We had a busy and productive third year of the TRAILS project. We expanded TRAILS to a total of four pilot courses across the country, initiated an evaluation plan, and began publishing our lessons learned. Two new courses came online: one at Drexel University and the other at Penn State University. Drexel pioneered a new feedback process that enabled master teachers to comment on evolving projects. Penn State experimented with a new multidisciplinary model, combining a graduate seminar in Instructional Systems Design and an undergraduate course on Human-Computer Interaction.

Our new comprehensive project evaluation plan features an innovative student survey instrument for assessing the impact of a project-based design course on students' notion of content knowledge, processes, and design values. Additional evaluation instruments include debriefings with instructional staff and selected students after each TRAILS course; a protocol for reviewing the structure of each course through its syllabi, activities, and readings; and analysis of course artifacts, such as projects cataloged in our Gorp Web application (<http://trails-project.org/webapps/gorp/>).

Meanwhile, our veteran partners at Stanford University and the University of Colorado at Boulder (CU) implemented major improvements to their previous TRAILS courses. Stanford adjusted how students interact with educator-partners and added group participation to the grading rubric. CU worked to manage student expectations by rechristening its course “Gamelet Design.”

## Activities

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

Below we list our major activities over the past year in University Education, Collaborative Software Design, and K-12 Classroom Impact, followed by more details about work done at individual partner sites.

### University Education Activities

Overall in Y3 of TRAILS, 89 university students participated in a TRAILS-affiliated course across our network of 4 institutions. A demographic survey of all but the Drexel course revealed that 69% of the students identified themselves as white and 74.6% were male. The table below provides more demographic information.

	Stanford	Colorado	Penn State
<b>Students Surveyed</b>	12	16	38
<b>Age (years)</b>			
Mean	26.7	21.3	23.4
<b>Year in College*</b>			
Mean	4.9	3.1	3.9
<b>Gender</b>			
Male	33%	77%	87%
Female	67%	23%	13%
<b>Ethnicity</b>			
White	42%	93%	74%
African-American	0%	0%	3%
Hispanic/Latino	8%	0%	3%
Asian	33%	7%	17%
Other	17%	0%	3%

\* Year in College is calculated by assigning freshman through graduate student a code of 1 through 5.

The courses used a mixture of instructional techniques and activities, including lecture, discussion of readings, opportunities for group work, review of existing educational technology, and presentations by guest speakers. A few syllabi indicated that students would also engage in team building activities. Courses required students to use design journals to capture sketches and design ideas as well as reflections on the readings, all of which were assessed by the instructors.

As a means of evaluating TRAILS courses, the team developed a new pre-post survey designed to measure how students' perspectives on learning-technology design change in three categories: content knowledge, project process, and design values. This survey was administered to all students in winter and spring 2005 courses. Preliminary results from the survey are outlined in the Findings section. Details are found in a paper submitted to the International Computing Education Research (ICER) workshop (see the Publications & Products section).

### Collaborative Software Design Activities

SRI evolved the TRAILS Gorp Web application for cataloging student projects. On the basis of feedback from Drexel, the team at SRI altered the Gorp interface and schema to better support a phased design process and to give teachers more flexibility in choosing which facets to use. Other new features were implemented to aid searching and browsing. A new search engine

allows users to look for curriculets by keyword. Users can also browse the collection by institution and course year. Students can also acknowledge the specific work done by each member of a team by filling out a new “Credits” data field. With the revised Gorp, students can attach arbitrary files to their project to capture external artifacts, such as Word documents and executables (e.g., applets). Gorp automatically displays a link to launch applets to make it easy to sample student projects.

SRI also prototyped an experimental new environment for the joint design of Web-based applications called the Browser-based Interpreter for Collaborative Computation over the Internet (Bicci). The Bicci concept draws ideas from the success of wikis but makes computational objects (e.g. small programs) as easy to edit, share, and execute through the browser as text can be manipulated in a wiki.

CU continues development of its end-user development tool for collaborative 3D game authoring, which includes support of interdisciplinary design and development. They prototyped several XML-based project representation schemes in support of end-user and expert-level developers.

### **K-12 Classroom Impact Activities**

Drexel conducted an experiment on course feedback mechanisms that could be used to increase not only student learning but also the ultimate educational value of TRAILS projects. Course staff in the Computer Science Department and the Math Forum @ Drexel pioneered a feedback process whereby teachers comment remotely on each iteration of a project. This was piloted in the fall Drexel course, with eight teachers providing regular commentary on the four student projects. Drexel also played a key role in specifying new TRAILS Gorp features to support teachers’ adding feedback.

### **More Activities at Drexel University**

Drexel University’s Department of Computer Science developed and offered a new TRAILS-affiliated course titled “Educational Game Design” for fall 2004. Frank Lee was the instructor of record and Yelena Kushleyeva the research and teaching assistant. Suzanne Alejandre and others at the Math Forum were closely involved in the course design, guest lecturing, and providing feedback on course projects (through the mechanisms described in the preceding paragraph). For the Drexel instructors, the TRAILS course reinforced the value of extensive and innovative feedback mechanisms.

In addition to providing pedagogical support to the computer science class, the Math Forum was involved in (a) cataloging TRAILS products for the Forum’s popular Math Tools site (see the Publications & Products section), (b) studying employers’ perceptions about the training and needs of students learning to develop educational software, and (c) studying issues of feedback in the Drexel TRAILS class. The study of employers’ perceptions was intended to inform TRAILS partners about what those in industry (business and educational technology) with whom we had contact (but who were not directly involved in the TRAILS effort) perceived to be content knowledge and capacities that students need in order to work successfully in their business environments.

The study of the Drexel TRAILS class is examining student motivation for and learning from educational content inserted into a course on gaming. Data include student applications to participate in the course, student written feedback following the course, descriptive questionnaires collected the first and last days of the course, student work with teachers on design projects, teacher feedback on the design projects, and observational notes. The study of the TRAILS classroom has been undertaken as a collaboration of K. Ann Renninger, Frank Lee, Suzanne Alejandre, and Allen Frost. Data reduction and analysis have been completed, and three papers are in preparation (see the Publications & Products section).

### **More Activities at Stanford University**

Stanford used the fall of 2004 to revise its TRAILS course design for winter 2005, based on observational and interview data from the previous course. Changes in the course design included increased interaction of students/groups with partner educators, more readings in the design and assessment of student learning, the addition of group participation into grading criteria, the attendance of partner educators in final project presentations, and the use of Gorp as an environment for project development. Stanford found that students appreciated the additional readings on learning research and curriculum development. They also valued the revised grading rubric, which set a higher standard for the comprehensiveness of projects. Students liked the readings on assessment but would have preferred them earlier in the quarter.

The revised winter 2005 course also added new sessions with professionals in education and technology. Three guest speakers talked about their biographies and work in education and technology. Two of the sessions were videotaped, and Stanford is working on plans for posting videos on project Web pages. Another addition to the winter 2005 course was “coaching” by prior TRAILS students. Both current students and alumni enjoyed these interactions.

Final projects were quite varied: an interactive DVD to use in a sex education class for teaching refusal strategies, an applet on maximizing geometric volume by changing an object’s linear dimensions, an interactive exploration of Titan, and a lesson on geographic bias in news reportage. All groups clearly put a lot of work into the projects and seemed to have had a great experience working with the teachers and in the classroom. Each group had specific ideas for next steps, and there was definite interest in continuing to work on the projects in independent study or master’s projects.

Stanford began work on activities and structures that contribute to TRAILS resources for career trajectory building. Stanford took the brainstorming ideas from the summer Partners Meeting and developed a series of activities for the Stanford course that can be useful to other courses and TRAILS students in general.

### **More Activities at the University of Colorado at Boulder**

The Computer Science Department at CU (CU-CS) shifted its TRAILS course design from high-end 3D games programmed from scratch toward “gamelets” (e.g. Namco’s Pac-Man or other games simple enough to work even on cell phones). This shift allowed CU to give its students more time for learning and fun analysis. CU’s spring 2005 course was titled “Gamelet Design for Education.” CU launched a new student recruitment campaign in fall 2004, with specialized ads for teacher participants. They distributed two versions of a course flyer, one for CS students and one for Education students.

Students completed five projects, including a simulation of an archaeological dig, a math gamelet in which students calculate a car's jump off a ramp, and a maze game requiring skills in math operations to navigate. They also worked on a project to teach loops and arrays to entry-level college students. Instructor Alex Repenning notes that students grappled with the challenges of balancing engagement with educational content, but he believes there was a better balance this year than in previous instantiations of the course. Students also discovered interesting things while user testing: one group (Osiris) found that undergrads had no difficulty playing their game, but grad students, who were older, lacked the required game play intuition.

CU's theoretical activities included the development of a conceptual framework, the Learning/Engagement Continuum, as a vehicle for discussing and contrasting different design perspectives (e.g., backward design, game design). They also devised a design process, called "Gamelet Design," focused on teaching simple but applied game design. CU's technical activities included supports for collaborative software design (mentioned earlier) and the use of a combination of TRAILS tools to create the Gamelets for Education Web site: Gorp to collect student materials and Yahoo Groups to support chat, e-mail, and file sharing. CU also refined its DeepNav system as a way to easily maintain its course Web site. DeepNav has been made available on several Web sites, including Apple.com, and has been downloaded several thousand times.

CU led numerous outreach activities (see the Outreach section), using modified versions of TRAILS course materials to expose people to gamelet design. CU believes that the idea of using game design for motivational and conceptual scaffolding is gaining interest and sees it as a way to counter the growing lack of interest of high school students in IT (e.g., documented by ACM).

CU's Department of Communications (CU-Comm) played a central role in the Y3 evaluation. They conducted debriefing sessions with course staff and one or more representative students for each of the four Y3 TRAILS courses. CU-Comm also created a mockup of a dynamic new Web site for the TRAILS network with various opportunities for community-contributed artifacts. They also conducted an initial literature review of online communities and how they organize best practices, such as for teaching TRAILS-like classes.

### **More Activities at Penn State University**

In fall 2004, Penn State ran a pre-TRAILS control version of the undergraduate course on Human-Computer Interaction, and collected baseline data with a variation of the TRAILS survey. In spring 2005, the TRAILS-coordinated courses were run at Penn State, combining a graduate seminar in Instructional Systems Design and the undergraduate course on Human-Computer Interaction. Students took on 10 projects and have written up detailed descriptions of them in Gorp. Instructor Chris Hoadley added new categories to Gorp, including "Educational Design Criteria," "Interaction Design Criteria," and "Design." Projects ranged from a multiplayer adventure game teaching math to online driving simulations to designs using the "technology" of board games.

Students from Penn State TRAILS met with the KidsTeam at University of Baltimore, a participatory design team led by Dr. Nancy Kaplan, which involves middle school students in the design of technologies for their age group. Children gave advice and feedback to the university students through an online videoconference, project feedback (including videotaped design

critique, serving as subjects for an interview on youths' interests, and test playing an educational game), and a face-to-face visit.

Penn State's theoretical activities included the refinement of rubrics for validating educational technology design.

### **Other Activities**

- The TRAILS team met on the Drexel campus in Philadelphia for the summer 2004 Partners Meeting on August 18-20. There we established Y3 research directions, and staff from previous iterations of TRAILS courses shared lessons learned for emerging courses. The winter Partners Meeting was held at Stanford University on January 14-15, 2005. Highlights from the meeting include an analysis of the successful feedback process used by Drexel, discussion of future funding opportunities, Gorp training, and planning for several paper submissions.
- SRI developed an approach for recognizing student projects with the goals of raising the bar for the quality of student projects, providing job-seeking capital for graduating students, and highlighting to the public the great designs emerging from the project. The process involves selecting a project, interviewing students and course staff, postproduction work on the project artifacts, and publishing an article on the TRAILS public Web site.
- SRI received complementary funding as a subcontractor for the ALASKA project (Agent and Library Augmented Shared Knowledge Areas), led by the Air Force Academy and sponsored by the NSF CRCRD program. The subaward will allow SRI to effectively expand the TRAILS network by advising the Air Force Academy on creating a TRAILS-like "practicum" in which students will create tools for learning about programming. An initial tool was created in collaboration with a team from the CU TRAILS course, a game-oriented learning module for the RAPTOR programming language.

## Findings

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

Four important lessons have crystallized for us in Y3 of TRAILS:

1. Design feedback from learners and educators is critical for TRAILS students.
2. Game orientation is a powerful motivator, as long as it is well bounded.
3. Multidisciplinary teamwork in higher education is valuable, but difficult to achieve.
4. Central supports for a course network require market analysis, packaging, and advertising.

We describe each of these below and list other findings in K-12 classroom impact and collaborative software design.

### **Design feedback from learners and educators is critical for TRAILS students.**

All four of the TRAILS courses report that design feedback from either target learners or experienced educators is critical for university students learning technology design. The variety of feedback strategies used by each course suggests that there may not be one ideal feedback mechanism; what matters is that students have the opportunity to get reactions to their ideas. The importance of educational feedback is also supported by preliminary findings from Drexel's study of employers' perceptions. Survey responses indicate the need for "testing, testing, testing" and "pedagogical direction."

At Drexel, student design documents were critiqued remotely by a team of educators who added textual annotations to elements in each project's Gorp entry. Drexel found that close university/K-12 collaboration through a feedback process can be enormously fruitful for both the students and the course instructors. However, the researchers noted that typical university students have little to no experience with structuring their work on the basis of feedback from external collaborators, be they teachers or professionals from some other field. For this reason, courses need a well-planned system for encouraging and promoting responsiveness to teachers' feedback. One such approach adopted by Drexel was to require students to respond to teacher feedback with a "cover letter" that explained how they addressed the teachers' concerns. Such mechanisms can increase the likelihood that students worked with and learned from teacher feedback.

At Stanford, each team was required to identify and meet with a practicing "partner educator" who acted as a client. Each team was also encouraged to consult with content experts in the material the team was trying to teach. Students seemed to take advantage of content experts, and the final projects showed evidence of their discussions. As in previous years, field tests and observations in the classes of partner educators continued to be "eye-opening," benchmark events for the students. Students all indicated that it is well worth the extra effort. Stanford also found indications that increased requirements for interactions with partner educators enhanced not only the quality of resulting projects but also the group process.

Both Penn State and CU adopted a "play testing" strategy, which is now commonplace in computer game and toy design. CU arranged for its TRAILS students to share their prototypes with children in a computer club at a nearby middle school. The TRAILS instructor, Alex

Repenning, reports a similar “eye-opening” effect as at Stanford. Penn State TRAILS students traveled to Baltimore to drop in on a weekend workshop with middle school children and receive feedback on their designs. Prior to this face-to-face experience, children in this workshop gave advice and feedback to the TRAILS students through an online videoconference. Penn State’s experiences suggest that involving children in the university students’ educational technology design training is a feasible and motivating way to improve undergraduate and graduate education.

Regardless of the feedback mechanism, TRAILS students are hearing the message that feedback is important, and the earlier the better. Our cross-institutional survey of TRAILS students revealed a significant increase from pretest to posttest in the value that students placed on earlier feedback on their designs.

**Game orientation is a powerful motivator, as long as it is well bounded.**

Both of the pilot TRAILS courses that have a game orientation in their learning technology projects reported many advantages to the focus on gaming. Drexel found that although students may have different levels of interest in learning about educational content, the context of game design helped students learn about and get practice in educational content. CU found that the notion of “gamelets” helped focus the design processes that they promoted in their class. When scaffolded with the right process and tools, CU students could engage in learner-centered, iterative development approaches resulting in a good balance between learning and engagement goals. A study by CU undergraduate Kavita Agrawal found that a game design orientation has the potential to get more women involved in information technology. However, game design needs to be conceptualized as a social design process including nonprogramming activities, such as the creation, selection, and sharing of art and sound.

Both TRAILS courses found it important to bound the game designs that students took on. Drexel accomplished this by asking students to focus on design *documents*, not prototypes. CU learned from previous instantiations of its course to emphasize small games at the level of Pac-Man. CU found that its gamelet design process could even be compressed to a single-day workshop to teach people with no programming background how to design and implement simple games.

**Multidisciplinary teamwork in higher education is valuable, but difficult to achieve.**

We continue to believe that multidisciplinary teamwork is one of the most effective means of achieving high-quality designs for learning technologies. This belief was supported by the preliminary results from Drexel’s survey of employer perceptions, which found a common need for collaboration among educators, students, and developers. However, our work has also highlighted the complexities of multidisciplinary teamwork in higher education. Not only do TRAILS instructors and staff struggle to find ways to best organize and incentivize student teams, but students themselves are surprised by the effort involved in coordinating their work. One source of evidence is our cross-institutional survey of TRAILS students, which revealed that students initially underestimate the frequency of project team meetings for joint decision-making. Penn State data showed that students benefited from interacting with others from different disciplines and enjoyed working on educational technology projects. However, students highlighted difficulties with coordinating graduate and undergraduate students’ work schedules.

## **Central supports for a course network require market analysis, packaging, and advertising.**

In growing the network of TRAILS-affiliated courses this year, SRI encountered new challenges in providing useful central supports. As the network has grown, SRI has found itself trying to support a greater range of teaching goals, more diversity in knowledge of learning technology design, and an increasing variety of teaching styles. Our semiannual face-to-face “Partners Meetings” have proven to be one of our most effective means of building consensus around principles for teaching learning-technology design and sharing informal course design knowledge. Less effective have been our electronic resources, such as our reading list, which we had hoped would provide a common foundation of literature for our courses. When we reviewed the readings that were actually listed in the syllabi of TRAILS-affiliated courses, we found that a disappointing 20% of the readings came from our centralized list. Transfer of activities captured in our Web site from one course to another has also been limited.

It has become clear that, even among formal partners, the effective sharing and transfer of course resources must be managed like a commercial enterprise: significant time and energy must be devoted to market analysis, packaging, and advertising. SRI needs to be more careful to understand the needs of instructors, organize resources in a portable form that allows for local adaptation, and then advertise these resources across our network. This realization has motivated us to create a needs survey for higher education instructors that we are administering at our ED-MEDIA symposium (see the Outreach section).

When it comes to technical resources such as Gorp, SRI found that a course instructor is less interested in tools to support design reuse across institutions than in tools that help students organize projects in terms familiar to the course. SRI also found that project content stored under individual student accounts is at risk of being lost, so there is a need for ways to archive projects effectively. These realizations caused SRI to iterate on the design of the TRAILS Gorp system, adding support for course-specific categories of information for student projects and ways to upload project content for the long term onto SRI servers. Consequently, SRI changed the meaning of the Gorp acronym from “Gallery of Reusable Projects” to “Gallery, Organizer, and Repository of Projects.”

### **Additional Findings in K-12 Classroom Impact**

- Drexel researchers found that design students came to understand that there are standards for supporting K-12 students in learning mathematics and that these focus on the process of mathematics, the utility of supporting reflection, and the goal of educational game design to stretch student thinking.
- Compared with the Math Forum’s involvement in previous TRAILS courses (occasional e-mail exchanges with students, the 20 Questions activity, etc.), the interaction with the Drexel course was exemplary of the master-teacher role that the Math Forum has sought to play. The feedback process helped steer students toward designs that had the best chance of positively affecting the classroom.

### **Additional Findings in Collaborative Software Design**

- CU-CS found that the combination of XML-based representation schemes including meta information with hierarchical file and folder container models can produce project

representations that are significantly more shareable and annotatable than traditional project representations.

- CU-CS found that for a large class of simulation applications the cognitive load involved in authoring 3D simulations can be reduced to the same level as authoring 2D simulations. Using mechanisms such as Inflatable Icons, it is possible to create 3D games having the same conceptual complexity as 2D gamelets.

#### **Other Findings**

- SRI found that although instructors appreciated the value of centrally recognizing student projects, the general view was that they did not want this to become a competitive process. Instructors worried that a competition would detract from the collaborative spirit that has been the hallmark of TRAILS-affiliated courses.

## Training & Development

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

- This year, Penn State added two new graduate students to the project, Charles Cox and Paula Bach. Each learned about the content areas (HCI and educational design) and gained experience in both design pedagogy and research on design (design studies). Each attended a conference as a direct result of participation in the project. Both served as TAs for the TRAILS courses (Cox for Education, Bach for IST) and as helpers in designing and conducting the research on TRAILS.
- This year, Drexel also added a graduate student, Yelena Kushleyeva, to the project. Kushleyeva was involved as both a course TA and RA for Frank Lee.
- CU-Comm added a new graduate student, Stacy Wieland, who worked with fellow graduate student Jacob Dickerson (involved in TRAILS since Y2), to assist with course analyses and facilitate debriefings among course staff at Stanford, Drexel, Penn State, and Colorado.
- Jacob Dickerson (CU-Comm), Angela Booker (Stanford), and Emma Mercier (Stanford) continue to be involved as graduate research assistants in TRAILS. Dickerson has been working on appropriate methods for capturing best practices across courses. Booker and Mercier gained training in course construction. Mercier is getting a great deal of training as a participant observer and an interviewer as she continues to document group process and collaboration in the classes. She has completed 29 interviews with students and partner educators over the past 3 years. Angela Booker has had considerable teaching opportunities as a Teaching Assistant. She has been leading discussion groups, lectures, and discussions of three readings, as well as advising students in the course. She has been doing a great deal of classroom and course management and is getting very well versed in issues surrounding those processes.
- Stanford's Shelley Goldman reports that several of her former TRAILS students have come back to her for career advice in learning technologies.
- Kavita Agrawal at CU-CS used TRAILS as a central case study in her undergraduate thesis. Agrawal was a student participating in the previous Games for Education course. The focus of her thesis was the exploration of girls' lack of interest in working with information technology. Agrawal conducted a formal experiment exploring how to get more women interested in information technology by using connections to games.

## Outreach Activities

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

- December 2004. Stanford's Shelley Goldman gave a keynote at a USC conference called Scholarship in the Digital Age.
- March 2005. CU's gamelet concept was used very successfully at the Women in Engineering Career Day at University of Colorado. Prospective students with their parents created simple games using AgentSheets.

- April 2005. Drexel represented TRAILS on a panel at the Consortium for Computing Sciences in Colleges' 2005 conference (CCSCNE 2005, <http://www.ccsne.org>), held at Providence College, RI. Their panel was titled "Innovation in undergraduate computer science education."
- May 2005. CU-Comm's Michele Jackson gave a panel presentation at the International Communication Association (<http://www.icaheadq.org>). Jackson participated in the discussion titled "Games and Human Interaction: Curriculum and Research."
- May 2005. Penn State helped expose middle school children to participatory design by having its TRAILS university students participate in the University of Baltimore's KidsTeam initiative.
- June 2005. CU-CS offered a full-day workshop titled "Game Design for Education" at the 4th International Conference for Interaction Design and Children (IDC 2005). Participants included members from the MIT Media Lab, the S.F. Exploratorium, and local teachers. By the end of the day, all participants had created two working gamelets. Participants learned how to use the gamelet design methodology to design and create interactive games. A hands-on experience illustrated the design method step-by-step. Participants worked in small teams to design, test, and publish two working gamelets.
- June 2005. Stanford's Shelley Goldman gave a guest talk at a conference on Digital Kids.
- July 2005. The team will host a symposium at ED-MEDIA 2005 in Montreal titled "Challenges in Developing Authentic, Multi-University, Cross-Disciplinary, Design-Based Courses."
- Summer 2005. CU-CS is planning to hold another gamelet-related training workshop for project NSF EHR #0226962, "SUNY-Brockport College and Rochester City (SCOLLARCITY) Math and Science Partnership: Integrative Technology Tools for Preservice and Inservice Teacher Education," \$3.4 million, PI: Osman Yasar. At the end of July, they will also run full-day gamelet-related training workshops for the High School Honors Institute in Colorado.
- Informally, CU-CS is teaching gamelets at nearby Centennial Middle School at its Friday afternoon computer club. About 20 participants have created sophisticated games so far.
- CU-CS is supporting external projects with gamelet design software and curricular content. Recipients include an NSF DGE project (#0338324, "Computer Science Resources for Memphis Area High Schools," \$1.6 million, PI: Linda B. Sherrell) and The Shodor Computational Science Institute (\$1.5 million, PI: Robert M. Panoff).

## Publications & Products

### New journal publications resulting from this work

- Repenning, A., & Ioannidou, A. (2004). Agent-based end-user development. *Communications of the ACM*. (This article was part of a special issue on End-User Development. Repenning was an advisor to the European Research Commission in starting this effort.)
- Repenning, A. (2005). Inflatable Icons: Diffusion-based interactive extrusion of 2D images into 3D models. *The Journal of Graphical Tools*, 10, 1-15.
- Renninger, K. A., Lee, F., Alejandre, S., & Frost, A. (in preparation). "Learning" in a course on educational gaming: What did they do? What do they think they learned? (The pedagogy of the TRAILS course at Drexel is described, and changes in student perceptions of their learning in the course are reported.)
- Renninger, K. A., Lee, F., Alejandre, S., & Frost, A. (in preparation). *Portraits of student developers: What do they think they want? What do they need?* (Data from student applications to take the course, their feedback at the end of the course, and information from structured in-depth interviews following completion of the course are reported and used as the basis for describing two types of students: those who valued the integration of educational content into their learning about educational game design and those who did not.)
- Renninger, K. A., Lee, F., Alejandre, S., & Frost, A. (in preparation). *Providing student developers with feedback: How?* (Focuses specifically on one aspect of course pedagogy: feedback from teachers about game design. Change in students' work with feedback and teachers' perceptions of the feedback process are used to inform a rubric for providing students with feedback in future iterations of this task.)
- 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 past 2 years.)

### New books or other nonperiodical, one-time publications resulting from this work

- DiGiano, C., Chorost M., Chung M., & Huang J. (2005). *Helping instructors scaffold students' design of educational technology projects*. Paper to be presented at ED-MEDIA 2005, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Montreal, Canada.
- Hoadley, C. M., & Cox, C. D. (2005). *Educating reflective learner centered designers*. Paper to be presented at ED-MEDIA 2005, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Montreal, Canada.
- Mercier, E., Booker A., & Goldman S. (2005). *Bringing collaboration front and center in a cross-disciplinary design course*. Paper to be presented at ED-MEDIA 2005, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Montreal, Canada.
- Repenning, A., & Clayton, L. (2005). *Playing a game: The ecology of designing, building and testing games as educational activities*. Paper to be presented at ED-MEDIA 2005, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Montreal, Canada.

- Repenning, A., & Ioannidou, A. (2005). *Mr. Vetro: A collective simulation framework*. Paper to be presented at ED-MEDIA 2005, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Montreal, Canada.
- DiGiano, C., Emery, D. K., & Molinas, A. (submitted). Student perspectives in project-based courses focused on learning technology design. Submitted to *Proceedings of the International Computing Education Research Workshop 2005*.
- Repenning, A., & Ioannidou, A. (Eds.) (in preparation). *What makes end-user development tick*. Book to be published by Kluwer.
- Agrawal, K. (2005). *Using games to get girls more interested in computers*. Undergraduate thesis, University of Colorado. <http://www.cs.colorado.edu/~ralex/temp/Kavi%20Thesis.pdf>

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

- TRAILS Gorp (Gallery, Organizer, and Repository of Projects): <http://trails-project.org/webapps/gorp/>
- Gamelets for Education Web site featuring the curriculum, homework, projects, references, schedules, and a discussion forum: <http://www.cs.colorado.edu/~ralex/courses/gamelet2005/>
- Selected TRAILS projects have been published on the Math Forum's Math Tools site: <http://mathforum.org/mathtools/index.html>
- The Math Forum created a Difficult Concepts List & Resources, highlighting particularly valuable math topics for TRAILS students to address: <http://mathforum.org/trails/concepts.html>  
<http://mathforum.org/trails/resources.html>
- CU-CS designed OpenGL for MCL: an open-source effort sharing a 2/3D OOD-based simple game engine. This code has already been used by several research organizations funded by NSF, DARPA, and European funding organizations.
- CU-CS designed XMLisp, a framework integrating an object-oriented programming language with the XML markup language.

## Contributions

TRAILS is uncovering 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 learning technology designers and to create exemplary digital content in the process. In the end, we anticipate that our work will affect 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

- In computer science, TRAILS is contributing to the field's understanding of the value of game-oriented courses. Such courses could bring back some of the energy and increase the enrollment in computer science. Nationwide, computer science programs have experienced an enrollment drop between 20% and 50%. This decline 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 courses that not only motivate students but at the same time provide enormous learning potential because of their integrative nature.
- In computer science and in education, TRAILS is contributing models for how students in project courses can receive authentic feedback on their ideas. At least three different models have emerged, which we plan to compare and contrast in a journal article.
- In computer science and in education, TRAILS is contributing models for interdisciplinary collaboration between university students.

### 2. Other disciplines of science or engineering

- We anticipate that lessons learned in computer science and education will transfer readily to the design of courses in other disciplines, such as a mechanical engineering project course.

### 3. The development of human resources

- TRAILS is fundamentally about the development of human resources for the design of high-quality learning technologies. Now in Y3 of the project, we have a growing collection of stories of alumni going on to do great things. At CU, students have credited the TRAILS course with helping them find better jobs because of their exposure to state-of-the-art technologies, including, for instance, artificial intelligence in game programming. Other students have become teachers and used some of the TRAILS tools and teaching materials. At Stanford, alumni have taken jobs in the technology sector, where they report they are applying their learner-centered design techniques.

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

- A central goal for Y4 of TRAILS is to ensure that design resources for instructors and students are appropriately packaged and disseminated so as to have a lasting impact on higher education.

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*What people have worked on your project?*

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