TRAILS Annual Report, August 2002 – August 2003*

INTRODUCTION

Training and Resources for Assembling Interactive Learning Systems (TRAILS) is an ambitious investigation into how to broaden and support the pool of talent available to create high-quality software for K-12 education. Our approach for a sustainable software production process is to create a general framework for involving university students in educational technology. This framework draws from best practices in project-based courses involving collaborative design.

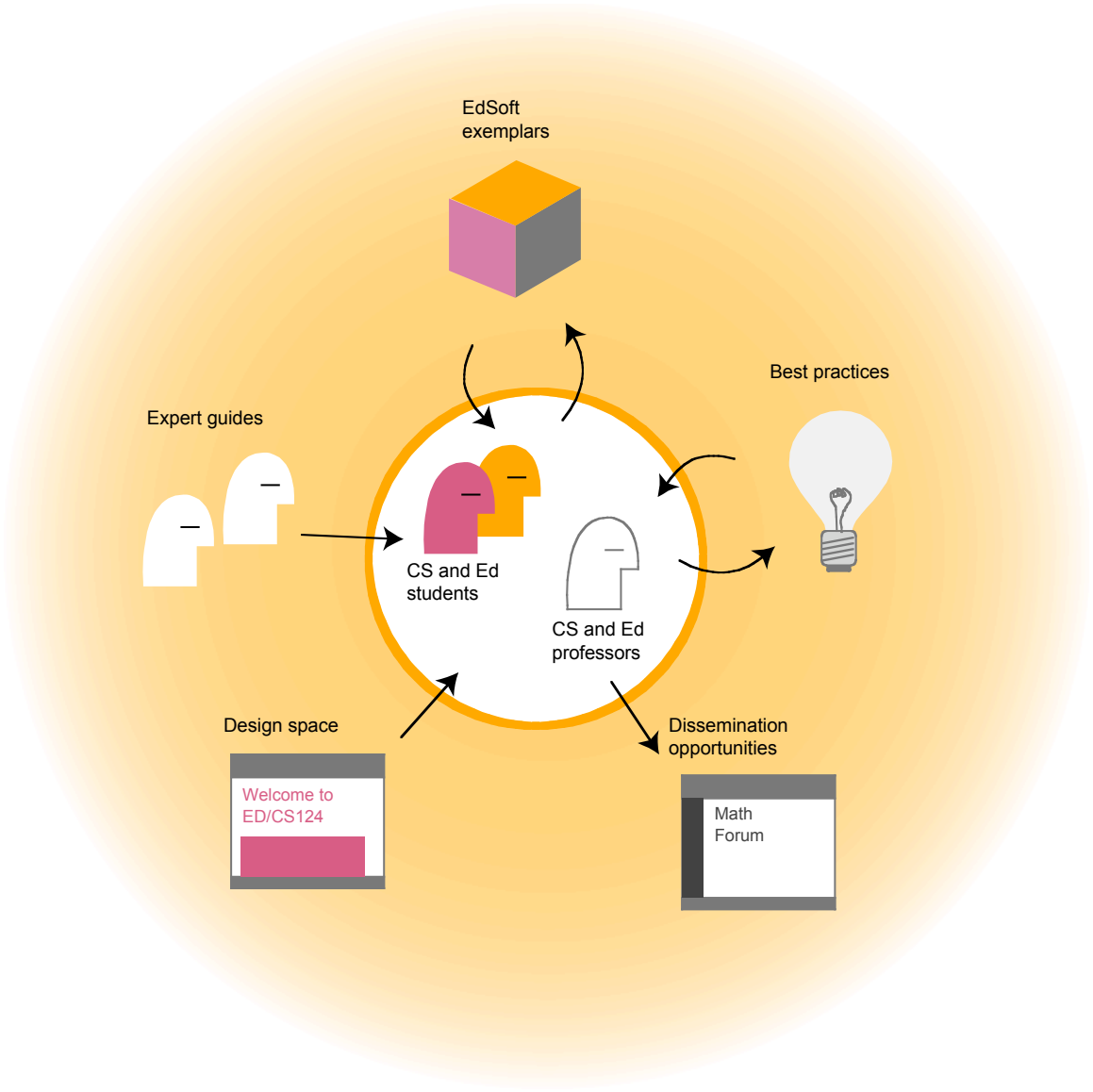

Figure 1. TRAILS resources for university course support.

* This report is actually a 13-month report, since TRAILS activities began in August 2002, one month in advance of the official start date of 1 September 2002. Note that activities for June-August 2003 are only *projected* activities, since NSF requires that award recipients submit annual reports three months in advance of the project anniversary.

To help train the university students, the TRAILS project is running experimental course modules, publishing on-line resources, and recruiting experienced mentors, as illustrated in Figure 1. TRAILS course modules focus on mutual understanding of educational requirements, shared elaboration of designs with modeling tools, building prototypes from components, and field-testing prototypes with students. The course modules are being developed and taught at Stanford and the University of Colorado at Boulder. TRAILS is also working with Math Forum at Drexel University to publish selected software created by TRAILS students.

TRAILS is focusing on three resources for co-design: (1) tools for designing and prototyping educational software, (2) shared spaces for design artifacts, and (3) access to a network of pedagogical and technical experts.

TRAILS research activities span three broad categories:

1. *Undergraduate Education*. How to generate effective course modules in support of educational software design.

2. *Collaborative Software Design*. Resources and coaching that enable effective teamwork between educators and technologists.

3. *Classroom Impact*. Addressing the shortage of standards-based, high-quality educational software for K-12 classrooms.

ACTIVITIES:

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

The TRAILS project spent its first six months establishing project infrastructure and identifying key research issues. In the winter, this activity quickly shifted towards TRAILS course design as we seized on opportunities at both Stanford and the University of Colorado to test the TRAILS university curriculum on experimental courses during the spring. This was six months ahead of our original plan, but we decided that the early experiences could help catalyze our curriculum design activities and give us more chances to iterate on our approach. The early experimental courses also helped jump start work on centralized tools and guidance for TRAIL students and instructors.

We established a prototype on-line "Design Space" where students and instructors can share intermediate design artifacts, where outside experts can review student work and offer commentary, and where final products can be archived. We chose an existing, full-featured and flexible content management system called "Tiki" as a starting point for the Design Space. Our goal was to quickly bootstrap our design support system without committing ourselves to developing a customized homegrown solution.

We also experimented with supporting students through "Trail Guides," experts who made themselves available through email, instant messaging, and, in some cases, personal visits to the TRAILS classroom. For each course this spring, we provided a technical Guide who could

advise students on issues concerning programming languages, configuration management, and general software architecture. We also provided a pedagogical Guide who could help students with their curricular focus, teaching strategy, and the organization of student materials and teacher guides.

Below we list more details about our project start-up activities for the first 6 months, and then list our major activities in Undergraduate Education, Collaborative Software Design, and Classroom Impact.

Project Start-Up Activities

- TRAILS partners participated in a Team Planning Meeting in August 2002 where we synchronized our vision through the drafting of a press release. Reviewed roles of SRI, Math Forum, Stanford, and CU. Developed basic year 1 calendar.
- Released TRAILS mission statement to press on September 16. Unveiled the informational Web site at trails-project.org, featuring the new logo. Got published in eSchools News & Heller Reports.
- Established a TRAILS team Wiki at http://firefly.ctl.sri.com/wiki/trails/Wiki?StartingPoints. Created email distribution lists.
- Recruited Mark Schlager from SRI to consult on Teacher Professional Development and mentoring issues. Recruited Michele Jackson from CU's Department of Communications to consult on multidisciplinary collaboration issues.
- SRI conducted literature reviews on the following topics: Software Quality, Software Engineering Education, Collaborative Learning in Higher Education, Educational Gaming, and Computer Science Education Best Practices.
- Stanford conducted a library search on design courses, design approaches, collaborative and participatory design, and best practices in designing and using educational software. Stanford passed information and references to larger TRAILS team.
- SRI made contacts in CU School of Education. Talked with faculty member Valerie Otero, who specializes in science education, about coordinating with her proposed STEM-TP project.
- CU created Video Game lab at the University of Colorado (3 PCs + 1 Mac)

Undergraduate Education Activities

- TRAILS partners participated in a strategy meeting in December 2002 to align curriculum development efforts at CU and Stanford. We decided that courses would have a clear 'home' department, although they may be cross-listed. Unresolved was the appropriate number of credit hours and whether this should depend on students' departmental affiliation.
- Parties agreed to exchange guest presentations for TRAILS course implementations. CU's Dr. Alex Repenning gave the first guest presentation at Stanford, providing a workshop on the use of the AgentSheets authoring tool. SRI Gave guest presentations at Stanford and CU courses: structuring design activity (DiGiano), reuse (Chung), and Wiki tutorial (Griffin).
- CU offered the experimental TRAILS course "The Art OF and IN Game Design," which focused on collaborative design and implementation of high-end (3D) games. The course filled up right away despite late as possible course announcement. The course popularity

suggests that there is strong interest in games implementation. The course curriculum made it clear that this course would be a lot of work for a 3-hour credit course. Despite the rigorous nature of the course, 19 students from four different departments (Computer Science, English, Fine Arts, and Psychology) enrolled and stayed in the course to the very end. Student worked on a large number of projects including two major projects resulting in very sophisticated games with high production quality values (e.g., http://spider.ctl.sri.com/tiki/tikibrowse_gallery.php?galleryId=6).

- CU explored how to restructure current CS curriculum to provide more opportunities for students to be part of project experiences.
- CU explored how to make project-centered courses sustainable by incorporating undergraduate students serving as support team for others: one team of students worked on middle ware (game engine), and the other teams worked on applications (games). The resulting push/pull of features required to make games between middleware and application teams were used as discussion in class to discuss object-oriented design principles.
- Stanford began meeting with professors from Education and Computer Sciences departments. This discussion covered TRAILS course modules and student recruitment. Stanford began working through the process of trying to cross-list the course in future years. Also, began to recruit teacher education students for course design teams. Developed the syllabus for a course to be offered in the spring 2003 quarter called "Collaborative Design and research of Technology-integrated Curriculum.
- Stanford developed the TRAILS course, "Collaborative Design and Research of technology-integrated curriculum" and actively recruited students. The course was cross-listed as CS377F, allowing it to count as en elective for undergraduate computer science majors with a human-interface major. Taught course for Spring quarter with 11 students: five graduate students and five undergraduate students. Five of the students came from the Learning, Design and Technology students from Education; four students came from Computer Science, and one student came from the symbolic systems program.
- Stanford research activities included pre course study of the practices of education and computer science faculty and students. Data analysis and write up completed by June. Conducted observational study of group collaboration throughout the course. Data analysis of this study to be completed in July and August. Conducted journal study on group collaboration (collected journals three times during the 10 week quarter.) and a mid-course evaluation. Data analysis to be completed during July and August.
- Consultant Michele Jackson facilitated debriefing sessions for both the CU and Stanford courses.

Collaborative Software Design Activities

Tools

- Developed prototype Design Space to support CU's experimental course. Rather than reflecting a preconceived design process, the Design Space is being used as a living experiment in the kinds of supports needed by courses. Provided a seed structure and let students, teachers, and TA's build their own pages (e.g. assignments, readings, group documents, and products.)

- Iterated on the Design Space to support the Stanford course. Lessons from CU helped this launch go more smoothly. Seeded design space with some basic content, then trained Stanford's RA on how to do it herself. Developed simplified permissions strategy.
- Provided Design Space support for both CU and Stanford. Made sure students could upload large files for assignments. Employed Bugzilla to track design space issues. Enabled unregistered visitors to view of most Design Space content to aid TRAILS project dissemination.
- Began developing special "tool" support for one-click access to interactive content.

Trail Guides

- SRI hosted key strategy meetings to develop the TRAILS "guiding" strategy. Chose to use TRAILS staff as initial guides, but extract key ideas for transfer to external guides for Fall 2003. Discussed ways for outside guides to offer input on technical designs and pedagogical approach.
- The Math Forum attended weekly Guide Huddle meetings where both CU and Stanford classes have been discussed.
- The Math Forum reviewed individual final project proposals for CU by listening to an audio file. Gave written educational focus feedback on the 5 final project proposals.
- The Math Forum joined Stanford's first class meeting via video conference to introduce the role of the pedagogical guide and establish a connection with the students. Provided feedback to Stanford student groups as they start on their final projects keeping a "time meter" to get an idea of how much time is reasonable.
- The Math Forum regularly read class notes and proposals on both the Stanford and Boulder Design Spaces.
- The Math Forum is continually thinking in general what the role of a pedagogical guide would be and how he/she might respond to the given tasks.

Classroom Impact Activities

- SRI and the Math Forum explored ways to employ the Math Forum's new Math Tools Web site as a dissemination vehicle for TRAILS products. Math Tools is already cataloging K-12 educational and technology tool needs and providing opportunities to publish applets.

Other Activities

- SRI submitted poster to ITiCSE, which was accepted for presentation in June.
- SRI attended SIGCSE 2003 in Lake Tahoe, CA.
- CU's Repenning co-chaired Workshop on End-User Development, CHI 2003, Fort Lauderdale, Florida.
- Consultant Jody Underwood attended two meetings where she presented her experiences as "executive editor" of ESCOT, a prior project related to TRAILS. She advised TRAILS partners on ways to incorporate similar measures of quality control and scheduling into the creation of university student projects.

Looking forward to next year's activities…

Below are some activities planned for year 2 of the TRAILS project.

- Create focus for a second iteration of pilot TRAILS courses at CU and Stanford, emphasizing even closer collaboration with pre-service or in-service teachers.
- Identify ways to decouple course implementation specifics from general desired outcomes.
- Explore how to mitigate the chasm between "interesting" and "educational" games.
- Explore customization strategies to enable end-users such as teachers to adapt existing educational resources to their needs and to align with educational standards.
- Iterate on design space to provide simple but invaluable supports for *finished* products that can run in schools.
- Identify ways for guides to be more effective in TRAILS courses and have a rewarding experience.

FINDINGS:

What are your major findings from the activities identified above?

Literature reviews conducted by Stanford and SRI revealed that TRAILS is blazing new paths in its approach for training students to create educational software across institutions. However, we did uncover useful background knowledge in the fields of computer science education, teacher training, computer support for collaborative learning, and design. We developed a way to characterize what was unique about the TRAILS approach as the "TRAILS TripleC": (c)urriculum centered, (c)ollaboratively designed, and (c)losely supported.

After implementing two experimental TRAILS courses in its first year, the project has found that the TRAILS curriculum needs to be thought of as course modules that can fit into a variety of university contexts. This variety of contexts requires that a Design Space be flexible in nature and extensible in its functionality. Since TRAILS resources are not typically part of undergraduate courses, students need support and encouragement to learn how to use and apply the Design Space and the expert Trail Guides to their projects. Without encouraging their use, the students are much less likely to use them. The cross-disciplinary nature of TRAILS courses requires structured teambuilding support. This includes highlighting the responsibilities of a well-mixed team and establishing checkpoints to design activities. Class assignments need to be submitted in a predictable way—according to a schedule and conforming to a predetermined structure. This predictable structure also would help Trail Guides to know what to react to.

Below we list more details about our findings in Undergraduate Education and Collaborative Software Design. We anticipate findings concerning Classroom Impact in year 2 of TRAILS.

Undergraduate Education Findings

- Pre-service teachers already have lots of required courses and students teaching time, so getting their participation is difficult. However, at least at CU, TRAILS could fill a gap in the School of Education course offerings, since there are few opportunities for teachers to learn about how to use technology effectively.
- Some self-selected university student teams lack the right mix of talent. The biggest problems came from headstrong individuals who pursued a strategy for too long before realizing it was not going to work. This might be alleviated by highlighting the

responsibilities of a well-mixed team, including the responsibility to check progress against a schedule.

- Frequent checkpoints to design activities tended to help students avoid falling into a rut. Asking students to publicly announce what they planned to deliver at the next checkpoint had the nice effect of getting students to promise non-trivial improvements and to generally take the checkpoint more seriously. Also, it was a way for students across teams to better understand the projects going on in the class.
- Although it would help for guiding, SRI probably does not want to be in the position of telling instructors what assignments to require and when they are due. Instead, we should find ways to *encourage*, not *enforce* standard deliverables. One approach would be to organize a competition (perhaps called the "Trailblazer Awards") that gives credits to students who organize their design activity in a specific way.
- CU found that a game design course is a great vehicle to bring together students from different departments and engage them in collaborative design and implementation activities. Game design is complex and requires wide background in computer science including: real-time systems, networking, algorithms, graphics (2D + 3D), math, human factors, design, artificial intelligence, software engineering, distributed software development, event handling, windowing systems.
- CU found that the general computer science student's perception of educational software is negative. They think of games as either being interesting *or* educational. CS students who want to build computer games are not motivated to make them educational.
- CU found that students would like to have more project-oriented courses but are not accustomed to their nature. Students are accustomed to solving small, throw-away "problems", (e.g., Implementing quick-sort and expecting that there is a right answer). Many CS students are not used to working in teams and prefer to work alone at home.
- Stanford found that the cross-disciplinary nature of the TRAILS activities introduces student recruitment challenges.
- Stanford found that the course is ambitious as a one-quarter course. Given requirement constraints in the different schools and departments, one quarter is the only real feasible time frame for which students will be able to commit.

Collaborative Software Design Findings

Tools

- It is too early to prescribe a template for a specific design process in the Design Space. But, since we have empowered instructors, TA's and students to modify the Design Space for themselves, we can observe what they build and learn from this.
- Students adopt different strategies for teamwork. At CU we saw groups that (a) scheduled a physical meeting a lab where they split into pairs around the computer and communicated by yelling across the room, (b) worked individually, but kept in close contact by Instant Messaging, sending work-in-progress by email, and (c) adopted version control software (RCS), but ran into problems when students tried to simultaneously submit and then integrate pieces at the last minute before an assignment was due.
- Key factors in getting students to take ownership of Design Space and start editing content include (1) getting students editing early through a guided warm-up activity

during one of the first class meetings, (2) providing regular studio time during or right after class when students can work on their content while experts are available for help.

- Undergraduate students need assignments, due dates and grades. Simply suggesting how to organize design activities at CU led to confusion. The students were more comfortable when the activities were explicitly structured as a series of assignments.
- Artifacts need to be indexed in at least two ways in the Design Space: by project and by assignment. The *by-project* index allows users to quickly browse the evolution of a particular project, assignment by assignment. A page with all assignments done by a particular team would be a source of pride for students. The *by-assignment* index allows users to quickly compare and contrast artifacts done by different teams at the same design stage. This would be particularly useful for instructors and guides for grading/review purposes.
- Probably the single most useful aspect of the Design Space was simply providing a convenient, centrally-managed place for all students to upload assignments. This freed instructors from having to find disk space and manage submissions. However, Stanford students had already been allocated disk space and a student home page, which competed with our Design Space. Artifacts from Stanford teams were sometimes split across the Design Space and these students' home pages, inhibiting browsing.
- Choosing an existing, full-featured and flexible content management system as a starting point for a Design Space, was a good way to jump start on-line resources for TRAILS. We realize we could easily have spent our first year just developing a minimally-functional on-line system. Instead, the Tiki system allowed us to have a Design Space in place even when TRAILS courses started earlier than expected. Also, the customizability of Tiki let us quickly experiment with various kinds of services for TRAILS students, instructors, and researchers. Tiki is extensible enough for us to create whole new kinds of services as needed.
- The software development environment used in TRAILS needs to be: (1) attractive to CS students, (2) easy to learn, (3) deployable to K-12 classrooms, (3) appropriate for generating pedagogically powerful visualizations, multiple representations, etc.

Trail Guides

- Students generally need extra motivation to take advantage of Trail Guides. One possibility is that instructors agree to give extra credit to students who follow through on guide suggestions. But, this means that the instructor needs to trust guide commentary and needs to find the time to regrade assignments after students revise them according to suggestions.
- Long technical workshops, such as those we conducted at Stanford, risk coming across as disconnected to students. Instead, we should try 15-20 minute technical previews of software development technologies such as AgentSheets, Java and Flash, and then offer optional longer events after students have committed to their programming environment.
- The Math Forum found that meeting the students and instructor(s) during an initial class meeting through video conferencing identifies the guide as an important participant in the class. Students have the guide's role clearly defined and expectations are delineated. The guide feels connected and has a sense of the tone of the class.
- The Math Forum found that to keep the guide involved with the projects, communication with the students and/or student groups is necessary otherwise the guide doesn't know

when/when not to offer ideas. Technical considerations should be made so that guides can view student products.
- The Math Forum found that working off-site can lead to a feeling of isolation which can affect the guide's ability to perform the tasks.

TRAINING & DEVELOPMENT:

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

Training and development is at the core of the TRAILS project, since we are creating university course modules and supports for the next generation of citizens who will either design or use educational technology. In addition to ed-tech training for university students were are also providing (a) research assistantships for graduate students, (b) teaching assistantships to select undergraduates, and (c) new skills training for the project's professional staff. Below we list our major training and development activities that fall outside of the basic TRAILS curriculum.

- Two graduate research assistants from Stanford's School of Education, Angela Booker and Emma Mercie, played keys roles in designing, implementing, and evaluating the Stanford curriculum.
- A new research assistant was recruited for CU's Ph.D. program, Jennifer Turney. Jennifer is currently learning about TRAILS through a summer internship at SRI and will begin working under CU's Repenning in Fall 2003.
- Three undergraduate TAs were selected to help with the CU course. They gained experience in building a complex software tool (a game engine), maintaining it, and supporting it, teaching how to use it to the rest of the students. This experience was modeled after a previous experiment with a Fall 2002 course, Object-Oriented Design, where undergraduate TA's supported 40 students and implemented 3D algorithms for use in the course.
- Co-PI Repenning gained new teaching skills for conducting project-oriented and interdisciplinary courses.
- The Math Forum's Suzanne Alejandre gained experience and knowledge about new technologies for teaching and learning, including AgentSheets and Tiki.
- SRI's Jeff Huang gained project leadership skills by drafting TRAILS reports and submitting these to the Fastlane system.

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.

- Press Release resulted in: Ed-Tech Competition--Coming to a Campus Near You? Heller Reports. Vol 8, No 6. December 2002.
- Press Release resulted in: Branigan, Cara. $3.2 million grant trains college students to design school software. eSchool News. October 3, 2002. http://www.eschoolnews.com/news/showStory.cfm?ArticleID=4010.

- Joint effort with IBM's eMentoring initiative: AgentSheets simulation authoring software and AgentSheets activities (result also of prior NSF funding) were used at Heatherwood elementary school to introduce sixteen 4,5 graders to math and science topics. 8 such workshops took place.
- DiGiano, Chris (2003). Innovators versus Laggards: The Realities of Deploying Technology to Schools. Presentation to Univ. of Colorado graduate course CSCI 6838, April 2003.

PUBLICATIONS & PRODUCTS

Journal publications resulting from this work

- Stanford's Angela Booker will complete an article based on the initial study of TRAILS course participants' communities of practice

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

Two papers exploring how to use end-user development as means of customization especially of Web-based interactive content:

- Digiano, C., Griffin, M., Huang, J., & Chung, M.. (To appear Jun 2003) "Consolidating Ed-Tech Co-Design Best Practices through the TRAILS Project", Poster to be presented at Innovation and Technology in Computer Science Education, Thessaloniki, Greece 2003
- Repenning, Alexander, "The Pragmatic Web: Customizable Web Applications", Proceeding of CHI 2003, Workshop on End-User Development, Ft. Lauderdale, FL. 2003.
- Repenning, A., and Sullivan, J., "The Pragmatic Web: Agent-Based Multimodal Web Interaction with no Browser in Sight", Proceeding of Interact 2003, Zürich, Switzerland, 2003.

Web site or other Internet site resulting from this work

- Public Web site for TRAILS Project <http://trails-project.org>
- Prototype Design Space <http://spider.ctl.sri.com/tiki/tiki-index.php>
- Stanford Design Space <http://firefly.ctl.sri.com/tiki/tiki-index.php>
- Game Engine called Contra <http://schenkc.freeshell.org/classes/csci4448/contra/> UberContra: a 2D/3D Game Engine to quickly build agent-based games. Agents can be in grids or in continuous space.
- Object Oriented Design Course <http://www.cs.colorado.edu/~ralex/courses/csci4448/>
- The Art OF and IN Game Design course, for CS, EE and FA majors <http://spider.ctl.sri.com/tiki/tiki-index.php>
- Math Forum ed software sales pitch <http://mathforum.org/~salejan/trails/guide.html>

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 field of computer science education. We have identified challenges in getting students from different disciplines to work together effectively. We have also identified key services needed to centrally support multiple implementations of our course modules. We believe these findings are also significant beyond our principal discipline. They point to some common issues in motivating and supporting teams of designers, whether or not these designers are students.

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, as illustrated in Figure 2. 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.

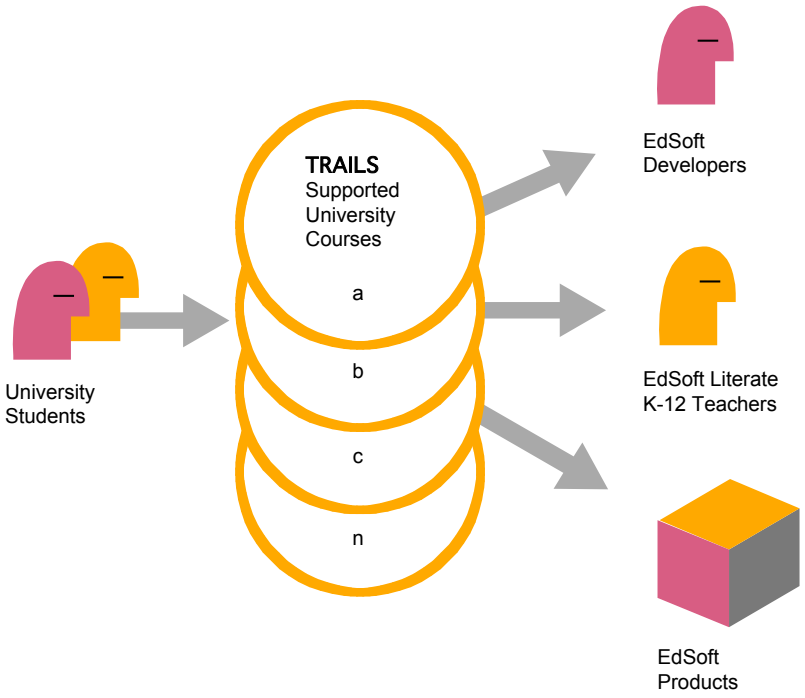

Figure 2. Projected TRAILS impacts on educational software production and use.

PARTICIPANTS

What people have worked on your project?

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