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SCIFAIR: A MULTI-USER VIRTUAL ENVIRONMENT FOR BUILDING SCIENCE LITERACY

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ABSTRACT
SciCentr.org is the primary outreach program for Cornell University's high-performance computing center, the Cornell Theory Center (CTC). Based on the metaphor of a science museum of virtual bricks and mortar, SciCentr runs a science communication fair program, SciFair, for teenagers at remotes sites around the Unites States. In 2003/4 extracurricular SciFair programs ran in five school settings. SciFair leverages online game technology and peer and coach/teacher mentoring to motivate teens toward continued participation in STEM education, to build Fluency in Technology (FITness), and science literacy. Preliminary evaluation of these programs based on survey data and observation suggests that the SciFair Model has the potential to engage teens in science communication projects through which they will build science literacy. We present lessons learned in terms of leveraging the medium of virtual worlds for constructivist learning for science literacy and the concept of a "playful knowledge space."

INDEX TERMS
Virtual World, MUVE, serious game, FITness, SciFair Model

INTRODUCTION

Young people in the United States who spend significant amounts of time online, watching TV, and playing computer games are not retreating into an antisocial world of their own creation (KFF 2005). Instead, these young people are as likely, if not more so, to participate in sports, spend time with their families, and doing homework. Moreover, a controlled study of the use of a video game to motivate and train young diabetes patients ages six to 18 (Brown 1997) demonstrated that "[v]ideo games can be highly appealing and motivating learning environments in which players have unlimited opportunities to rehearse skills, receive immediate feedback on performance, obtain and make use of information, experience social support when interacting with other players, and develop the confidence and ability to carry out new skills in their daily lives."

Through the *River City* project, Chris Dede has demonstrated that multi-user virtual environments (MUVEs) based on computer game technology can be used to effect improved mastery by mid-level students in middle school urban science classroom (Dede *et al.* 2004). Kerney (2005) reports that virtual worlds were used successfully to motivate and stimulate communication with Advanced Placement students in the Borderlink Project, an

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effort to prepare them for college careers. These were isolated teens, primarily of Latino heritage, in rural California. In particular, Borderlink students contributed more actively and with better arguments during an *inworld* debate over the ethics of genetic engineering held in the virtual world after visiting a SciCentr exhibit on genetic engineering in the Cornell Theory Center's universe of STEM educational worlds than they did in the classroom (private communication with Borderlink teacher).

Hein (1995, 1999) and others have confirmed the value of constructivist learning activities within the museum context. Several studies of programs for minority and underserved youth identify the importance of positive peer role models and mentoring for retention and motivation of participants (Miller 2003; Duffet and Johnson 2004). In addition, a recent article in the Chronicle of Higher Education (Farrell 2005) highlights the fact that the majority of minority college freshmen at schools such as UCLA are unequipped to manage the digital workplace. Thus the intent of the Cornell Theory Center's (CTC's) SciCentr and SciFair online outreach programs is to design activities within the virtual worlds that will spur interest in/pursuit of STEM education in youth in rural and urban disadvantaged schools. These programs support youth as they interact with custom content and as they create their own, personal contexts for specific research areas with support of trained coach/teachers and peer mentors. At the same time, these students build Fluency in Technology (FITness) (Anon. 1999) and self-confidence.

THE SCIENCE COMMUNICATION PROCESS

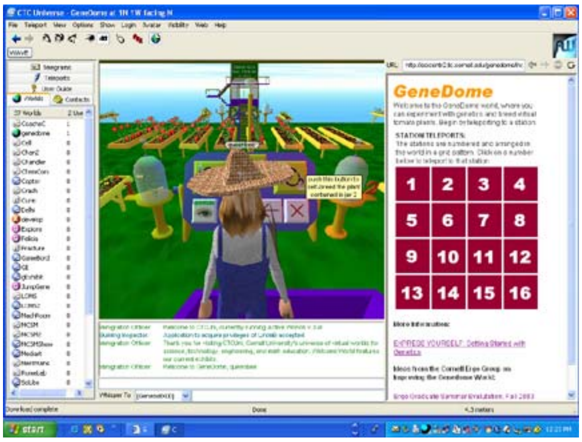
CTC, as Cornell University's high-performance computing and computational research center, hosts an online science museum, SciCentr.org. Founded in 1998, this museum exists only in Cyberspace, with most of the exhibits based in CTCUni, a universe of multi-user 3D virtual chat worlds based on Active Worlds technology. The premise is to leverage the appeal of multi-user online games to attract teens into the online environment and to offer educational science content and simulations in a fun and safe, social setting. Teachers and teens visiting SciCentr exhibits conduct experiments, explore exhibits, play "Serious Games," stage debates, and learn about current research while building their familiarity with current information technologies and computational science. SciCentr began with a small team of undergraduates and one rural after-school program and, while still a work in progress, has more than 1000 participants in 2004/5.

If SciCentr.org is a virtual museum made up of exhibits that you can explore via the Web or within a virtual world, then SciFair is the outreach division of this museum. SciFair brings teens behind the scenes where they work with staff, mentors, and trained coaches at their sites to research, design, and build their own exhibits. The SciCentr/SciFair Handbook has been developed to provide documentation for the program, in particular the SciFair Model, with references, sample forms, sample standards-based curriculum modules, and more for their support.

The SciFair Model is a social process for teens and coaches supported by Cornell undergraduate students and SciCentr staff through which they create online multi-user 3D exhibits or knowledge spaces. We have identified three natural stages to the process. Participants first master the new medium, which enables them to colonize a small piece of Cyberspace to build ownership in the program and to learn about design of game interaction. Teens also are introduced to basic "netiquette" and get to know their mentors. They engage in small projects that we call "inworld activities" through which they exercise standards-based math and technology skills.

Stage two encompasses topic research, exhibit design, and creation of a "knowledge space" featuring a particular issue/technology/phenomenon chosen by the team. SciCentr staff and mentors provide Web-based gateways to a selection of specific research areas and related examples from Cornell research. Students are encouraged to frame these areas of research within their own contexts. This generally begins with discussing what kind of space they want to build—a gallery, a maze, a landscape, a temple. For example, they can explore and present the history of our understanding of black holes inside a series of domes or find ways to artistically represent the interior of a cell looking at plastid functional genomics or create a landscape to present the ethical issues surrounding cleanup of nuclear waste.

Figure 1: The Medium: Active Worlds



- **Efficient Online System**
- **Secure Extranet**
- **Chat Technology**
- **Game Interaction**
- **Web Content**
- **Custom Features**
- **Open and Creative**
  - **SDK**
  - **Customizable**
- **Community Support**

Finally, the team shares its exhibit with peers from other teams and educational professionals online, at the same time demonstrating their work in person for members of the local community, peers, parents, school administrators, etc. In 2003/4 these events ranged from school board presentations to showcase opportunities at CTC-Manhattan and teen-led workshops at national conferences. Every program must plan some kind of Showcase in order to complete the process.

EVALUATION

Five sites completed successful year-long SciFair programs in 2003/4. Two additional sites conducted modest trials. More than 70 students participated in school-based SciFair programs at the five primary sites in 2003/4. Approximately 25 more teens participated in short term projects and internships. The outcomes of SciFair projects are graphically demonstrated in the spaces themselves, which range from an expansive set of mazes filled with quizzes and surprising facts about the tropical rainforest, to an elegant world created by coastal American Indians that includes slide shows about tsunamis and a multimedia gallery used by Cornell undergraduate researchers to present the results of their experience learning to create tsunami waves in a tank.

Figure 2. Quiz mazes featuring student visions of rainforests past and present. Student researched questions and answers for the game. In a Showcase, they coached new players through the game. For help in answering the question, a player clicks on the creature perched above the question sign, which activates a Web link and opens a reference resource in the Web window of the browser. (This leverages a standard feature in the software.) A mouse click on the correct answer teleports the player forward in the maze. The choice of an incorrect answers results in the players' return to the beginning of the maze.

SciFair evaluation includes preliminary surveys, ongoing team evaluation by mentors, and post surveys, including open ended questions. Sixty five students completed student information forms on which they identified their age, sex, grade, race (optional), and experience in math. Of the 65, 36 identified themselves as minority and an additional 9 came from a poverty-level community. There were 36 female and 29 males. At the end of the year these students provided the following general feedback on the program.

Overall Program Rating:
20 Excellent, 28 Very Good, 13 Good, 2 Fair, 0 Poor (2 no response)
I Would Recommend the Program to Others:
23 Strongly Yes, 29 Yes, 13 Unsure, 0 No, 0 Definitely No
The Program was a Useful Experience:
18 Very Useful, 25 Useful, 20 Somewhat Useful, 1 Minimally Useful, 1 Not Useful

Table 1. Student Ratings of the 2003/4 SciFair Programs

Coach/teacher response to the first year was overwhelmingly positive. All coaches returned for the second year with the exception of one who moved into an administrative position in the school district. This site continued its participation with a new coach.

While we are not able to use the data on changes in teen attitudes toward math and science due to a change in answer scale required mid-year by the external evaluators, qualitative responses from teens suggest mastery of new science literacy and pride in their work. The following are responses from one middle school minority site gathered in post surveys at the end of the 2004 school year support the program's value for building science literacy and FITness.

What did you accomplish in the SciCentr/SciFair Program that makes you proud?
Middle School Earth Science: "My experiment on Mercury, because I worked hard on it and I think it is interesting information to me."

> “We made an astronomy center in [TeamWorldName] 2 (A virtual world). We put the planet, a sun and made tunnels. It was very exciting.”
> “I learned more about the solar system.”
> FITness: “How to use a computer better.”

Data from the 2003-5 SciFair programs is contributed to the cross-program evaluation of the GE Foundation Math Excellence initiative by Campbell-Kibler Associates. Grade point averages and participation in STEM courses for all participants in year-long SciFair programs have been gathered for 2003/4 and 200/5. Ongoing relationships with two schools supported by the GE Foundation might ensure continued data gathering for students at those schools for a few more years. Tracking students at other sites after they leave the program is beyond our capability. We will track continuing coaches and mentors to evaluate the program’s effect on their FITness. In review of first year data, we saw teacher/coaches sustain or improve the use of new media in the classroom and overwhelmingly express the desire to integrate this program into their curricula. Only one teacher/coach did not continue with the program. This person moved to a district administrative level; the school continued to participate.

DISCUSSION

There is a large, up-front investment in bringing a SciFair site online. Coaches and mentors require training and the technical coordinator must establish a relationship of trust with technical staff at the site. Additional factors include teen recruitment and retention and extensive paperwork to enable evaluation. Regardless of these obstacles, teens, coaches, and mentors sustain their energy throughout the year and almost all coaches and mentors eligible to continue with the program do so.

Tools are needed to assess the knowledge spaces created by SciFair teams and we will be working with educational researchers to identify criteria for evaluation. More serious interviews during and records of Showcases will lead to better understanding of the program’s impact on science literacy. In addition, it is possible to analyze chat logs over time for a qualitative view of the interaction among mentors, coaches, and teens. However, we do not currently have the resources to perform this analysis. In addition, because the contexts of SciFair programs vary dramatically among the sites (one site focuses on math, another on digital media, another on life science), we expect the program’s impact on motivation to be site specific when we analyze the now-standardized 2004/5 data from eight programs at nine sites.

CONCLUSION

Each SciFair site is unique. Some of the programs are run in conjunction with curriculum programs and almost all coaches are teachers. These teachers want to apply the Model in their classrooms. While the informal programs serve to bring the program into the schools “through the back door,” there is great potential for curriculum application. Supplemental activities in SciCentr exhibits, Virtual Fieldtrips, can be coupled with SciFair Class Projects. This will require development of what we will refer to as the Classroom Building Framework, a streamlined and likely modular approach to the SciFair Model, with scaffolded support for coach/teachers and students. This project will be informed by the

Building Blocks for Virtual Worlds Projects (Borner, *et al.* 2003), a collaboration among Katy Borner (Indiana University), Margaret Corbit (CTC), and Bonnie DeVarco (Vlearn 3D SIG of the Contact Consortium).

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