A Pre-College Professional Development Program

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ABSTRACT
In this paper, we describe the results of a four-year collaborative project conducted among six higher education institutions and their partner pre-college school systems across the US. The primary goal of the project was to offer professional development to middle and high school teachers to enable those teachers to create modules and courses to excite their students about computing. The project used Alice, a software program that utilizes 3-D visualization methods, as a medium to create a high-level of interest in computer graphics, animation, and storytelling among middle and high school students, to build understanding of object-based programming. More than 100 middle and high school teachers participated in the project, with approximately 80% of those reporting that they had used what they learned during summer workshops in their classrooms during the subsequent years.

Categories and Subject Descriptors
K.3.2 [**Computer and Information Science Education**]: Computer Science Education

General Terms
Measurement, Experimentation

Keywords
Alice, pre-college, professional development.

1. INTRODUCTION
Five years before Cuny's ambitious 10,000 teacher project [2], the authors had a more modest proposal: Would it be possible to offer sufficient professional development to 100 middle and high school teachers, to help them improve the quality of computing instruction the teachers were offering their students? Regardless how well (or how poorly) computer science may be taught in college, college faculty cannot reach the students who are not sufficiently curious to at least take an introductory computing class. There is a second interest towards trying to expose more pre-college students to computing. Identified more than a decade ago by Snyder's NRC panel [6], and reiterated by many others, most recently in Rushkoff's new book [11], the reality is that all students need a certain competence with computing in general, and even with programming in particular.

We had good success using Alice in college [5]. Based on sales reports of Learning to Program with Alice [3], we were aware that Alice was being taught in pre-college (we guessed mainly in high school). So, it seemed natural to try to use Alice as part of a high and middle school program. In the US, middle school refers to students in grades 6-8 (ages 11-14), and high school typically refers to students in approximately grades 9-12 (ages 14-18).

We formed a team of interested college faculty and possible middle and high school teachers and school districts who were open to participating in this ambitious project. After a half-year of team-building, we identified the National Science Foundation's Information Technology Experiences for Students and Teachers (ITEST) program [13] as a potential funding source. The plan was to run a pilot program with the Virginia Beach School District (VBSD) starting in summer 2006, with implementation by the teachers during the 2006-2007 year. Modifications to the program would be made, with roll out to the Denver, Colorado, North Carolina, San Francisco Bay, California, and South Carolina areas during summer 2007 and to the Mississippi area in summer 2008 (with implementation by the teachers during the subsequent academic year). Participating colleges included Saint Joseph's University (working with VBSD), Colorado School of Mines

(Denver), Duke (North Carolina), Santa Clara University (San Francisco), College of Charleston and Columbia College (South Carolina) and the University of Mississippi (Mississippi). Dann and Cooper were to work with each of the colleges in preparing for their parts of the project. The team received notification in summer 2006 that its proposal was going to be funded, and the pilot program was run. However, the actual award was not made until February 2007, and each of the 2007 sites pushed back plans to run teacher summer professional development until summer 2008, with planned teacher roll-out in the 2008-2009 year (and in the 2009-2010 year for teachers who were not able to get necessary approvals in place for the 2008-2009 year).

2. THE PROFESSIONAL DEVELOPMENT PROGRAM

2.1 Teacher Recruitment

Teacher recruitment was accomplished by using existing college outreach resources, communicating with the appropriate state Department of Education officials to make teachers aware of the existence of this program, presenting at state teacher conferences/workshops, and by individually contacting specific schools. In fact, teacher recruitment turned out not to be a challenge as there were far more teachers who wished to participate than there were available slots. Teachers who wished to participate needed to fill out an application, and most needed to include a letter of support from the school principal.

There was a significant challenge in identifying the "right" teachers for the project. There was a desire to include multiple teachers from the same school, or at least from neighboring schools, to provide a sense of community once the teachers returned to their schools. There was also the desire to reach out to a wider variety of schools (geographic as well as the demographic of the types of students served) and teacher backgrounds. Each site chose a different set of criteria for selecting teachers. For example, the Duke site focused on non-programming teachers and consisted of mostly middle school teachers or high school teachers that did not teach computer science.

2.2 Logistics

Teachers were expected to participate in three aspects of the project: attending and participating in three weeks of summer workshops, using Alice in one or more classes during the following academic year, and reporting back on their experiences the next summer. Teachers were paid a small stipend to attend each of the three weeks of summer workshops. (In the US, teachers often work second jobs in the summer, and the stipend helped to offset the loss of income for the three weeks in which they would be working with Alice.) They were paid a larger stipend upon reporting the following summer about their experiences (and sharing their curricular materials and collecting required data). During each of the first two weeks of summer workshops in the first summer, and for the wrap-up meeting the second summer, teachers were provided housing either at or near the college.

2.3 The Summer Program

As per the requirements of the ITEST program, comprehensive programs for students and teachers track, participating middle and high school teachers were required to receive 120 hours of summer professional development. The 120 contact hours were broken up into three week-long 40 hour activities. The first week was a workshop focusing on teaching the teachers Alice. The location was at the partner college, with either Cooper or Dann or Don Slater traveling to the site to co-run the workshop with the local college partner. Slater was not an original part of this project, but as a master Alice instructor, was called in to help co-run several of the workshops. The second week focused on curriculum development by the teachers. Again, Cooper or Dann or Slater traveled to the site to co-lead the workshop (along with the college partner). The final summer activity was a one-week camp for students, led by the teachers who were trying out their curricular materials in a gentler environment (than in class), and observed by the college partner and by their peers.

There were a few differences across the summer program, most noticeably in North Carolina, where the focus was on middle school teachers who were not computing teachers. The focus of the first two workshops was for teachers to learn programming concepts and then have time to apply those concepts by working on Alice worlds related to their discipline. They would show their worlds during an animation fair and get feedback on them. There were two third weeks to split the teachers into two groups and to hold two one-week camps for middle school children.

2.4 Academic Year Support

The specific interaction between college and middle/high school teachers during the school year varied across sites. For example, in the VBSD pilot, Cooper traveled once a month to Virginia. Each month, he observed a different teacher teaching an Alice class. During each visit (which generally occurred when VBSD had in-service half-days), the team met in the afternoon to discuss various challenges they were facing, and innovative approaches individuals were using.

In North Carolina, Rodger visited one school. She also presented at the Durham Public School technical fair to show other teachers the work the team had been doing and also for recruiting teachers for additional workshops. Rodger had a few teachers visit her at Duke to show work and ask questions on worlds on which they were working. In South Carolina, Schep or Stalvey visited most teachers once a semester. Other sites made use of graduate and/or undergraduate students. Students were most frequently used to build specific virtual worlds to illustrate concepts for teachers, or to help teachers when they got stuck.

3. RESULTS

Results from the pilot project in Virginia Beach have been impressive. Four years later, Alice continues to be taught as the introductory computing class. There has been more than a tripling of students taking the introductory computing class (across the school district), with an analogous tripling of students taking the AP CS follow-on course. The increase in the number of women taking the AP CS class has gone from near 0% to almost 25%, and minorities also represent nearly 20% of the students. Further details are available in [1].

For the later sites where the professional development was run in summer 2008, with classroom implementation in either the 2008-2009 year or during the 2009-2010 year, it is still too soon to see the impact. The external evaluator's final report indicated that teachers who participated in the summer professional

development sessions saw a statistically significant increase in their programming and programming in Alice knowledge as demonstrated by on a content exam administered as a pre- and post-test at the start and at the conclusion of the program ($p = 0.000$ for teachers of all sites combined, indicating significance at $\alpha=.025$). The following remarks are drawn from the external evaluator analysis of several qualitative assessment instruments used in assessing our project. End of program (middle and high school) teacher evaluations showed that the teachers felt that the topics and instructional methods covered in the workshops were adequate for them to teach their students, and that interaction with partnering college faculty and college students met their needs. Teachers felt that Alice made programming fun and easier to teach their students. Teachers identified a myriad of benefits for classroom use of Alice. More than 90% of reporting teachers indicated plans to continue using Alice in their classrooms. There was a desire for additional follow-up (beyond the two-day wrap-up workshops) in future summers. There was also the desire primarily among middle school teachers to tailor Alice workshop instruction to specific individual subjects. In response to specific self-assessment questions, teachers believed that students enjoyed programming in Alice, students exhibited greater interest and spent more time on task and showed greater persistence in debugging programs, and were more likely to identify programming as a creative task. Teachers reported spending more time discussing objects and classes, as well as using more visual examples throughout their class. In summary, the evaluators concluded that there is evidence to support that significant advancement had been made towards the following goals: 1) providing and assessing teacher professional development, 2) enabling teachers to modify as appropriate, existing curricular materials, and 3) to establish partnerships as a network of K-12 teachers and local colleges at several locations throughout the US.

Perhaps one of the greatest impacts was not measured by the evaluators. This has been the continued excitement and enthusiasm by participating teachers. Not only are more than 80% of the participating teachers continuing to use Alice within their classes, they have been encouraging colleagues to adopt their materials, and going to local and statewide conferences to share what they have done. Another impact has been the surprising number of comments by teachers about their remarkable successes with special needs students, particularly with autistic children.

4. LESSONS LEARNED AND RECOMMENDATIONS

This section summarizes some of the items the team learned in working closely with middle and high school teachers over the past four years.

Difference in backgrounds among high school teachers: The absence of teacher certification for teaching secondary computer science is a challenge in the US. Depending on the state, mathematics, science, or business teachers are typically tasked with teaching a computing class. The teacher's field of study has a great deal to do with their previous programming experience. For example, mathematics teachers often are required to take a computing class as part of their undergraduate mathematics major. This is rarely the case for business teachers. Thus, teacher backgrounds (in terms of knowing how to program) vary greatly. As a result, it was a challenge to quickly and effectively instruct teachers of such varied backgrounds how to program using Alice (as the Alice content was taught over a one-week introduction). It was certainly possible to pair more experienced programming teachers with less experienced teachers, but it was quite a challenge to provide teachers who had little previous programming experience a sufficient exposure to programming in Alice in a week. While some of the workshop sites countered this challenge by including a non-trivial amount of Alice instruction in the second week (where the focus was intended to be curriculum development), the reality was that it probably would have been easier to have run the first week of Alice content in two separate two to three day workshops, allowing some time for the teachers to practice what they had learned. Unfortunately, our budget did not allow for this, and the logistics of flying Cooper or Dann to a site an additional time was more than we could schedule/handle.

Differences in backgrounds between middle and high school teachers: We did not initially create a completely separate workshop of Alice instruction for the middle school teachers. We had (wrongly) assumed that the high school workshop could be covered (albeit at a slower pace) by the sites that had either a large number or exclusively middle school teachers. This was not a realistic assumption. The middle school teachers had no previous programming experience and frequently less comfort with computer use. They were also often generalists, rather than specialists, so were required to know less content about more subjects. In our case, this meant that they had less comfort with mathematics, so that teaching functions and their use in Alice was more of a challenge. We also needed to spend more time with the middle school teachers helping them identify where in their curriculum they could place an Alice unit.

Importance of involving school IT directors: While we required interested teachers to obtain a letter of support/commitment from the school principal (guaranteeing sufficient institutional support), we did not likewise require a letter of support from the IT director. In several cases, the IT director was unwilling to initially install Alice on school computers leading teachers to either need to provide students with memory sticks with which to run Alice (in the cases where they had permissions to run software in this manner) to the more extreme case of delaying their teaching of Alice by a year while convincing the IT director that Alice would not damage the machines.

Continued involvement throughout the school year: While the summer workshops were an important kick-off, to get the middle and high school teachers started, it was the continued involvement during the academic year that helped to ensure the project's success. While each site handled academic year involvement differently, each site did continue the partnership between college and middle/high schools.

Showcasing teacher work: An Alice Symposium was held at Duke University on June 17, 2009 with over 120 attendees. Twenty-five refereed papers on Alice topics were presented in two parallel tracks. Presenters included K-12 teachers from all levels (elementary school to high school) and college professors. We describe a few of the topics presented. An elementary school teacher and participant at the Duke ITEST site spoke about lessons learned in integrating Alice into a 5th grade enrichment class. Other topics included using Alice as games, integrating Alice with Robotics, and curricula for integrating Alice into different K-12 levels. Two two-day workshops were held prior to

the Alice Symposium, one a follow-up workshop for Duke ITEST participants and the other an Alice 3.0 workshop.

Creating a community of practice: Ni [7, 8] explored reasons that teachers choose to adopt a new curricular approach. In particular, Ni identified the importance of "making the innovation fit and work in a local department." We believe that the continued partnership between Cooper and the teachers in the VBSD (and the frequent meetings throughout the school year) helped the VBSD team to make Alice work. In particular, the monthly meetings helped the team to develop what Fincher and Tenenberg [4] call a "Disciplinary Commons", a community where teachers teaching the same class can get together and improve upon each member's teaching.

A repository of teaching and training materials: Many teaching and training materials for using Alice 2.2 at the middle school level have been created as part of this ITEST project and made publicly available [10, 14]. This site includes tutorials, videos, and sample Alice worlds. The repository includes a variety of getting started tutorials from one hour to four hours of instruction, and over 40 tutorials on either computer science topics, animation topics or projects. Examples of computer science topics include functions, lists and variables. The titles of the tutorials try to appeal to middle school students, instead of using foreign-to-them computer science terms. For example, the title of the functions tutorial is "How tall are you?" Examples of animation topics include lighting, changing scenes and camera control. The videos and sample Alice worlds cover a variety of disciplines including science, language arts, mathematics, history, foreign language and music. Other materials available on this site are teacher participant lesson plans, schedules for using the tutorials in workshops, and sample worlds from teachers and students.

Teachers practicing their teaching of what they had learned: As part of the original ITEST grant, teachers were required to receive 120 contact hours. After the first two weeks of summer workshops (80 contact hours), the team decided that the remaining 40 hours would best be spent by having the teachers co-run (in partnership with the local college partners) a one-week "summer camp" for students, where the teacher would practice teaching with Alice. The impact of this 3rd week varied greatly. Some teachers felt it gave them the confidence to successfully teach with Alice during the next year, and that the feedback they received from their peers was valuable. (Teachers ran the camps in small groups, taking turns teaching and evaluating one another.) Others found this 3rd week to be less useful, and indicated that they felt they could have more productively used this time getting ready for their class. In North Carolina, during the third third week, the Duke team ran the kids camp. The teachers worked on lesson plans and observed the kids working. The teachers gained confidence in using Alice for their courses by seeing how easily the kids learned Alice and how excited they were to program in Alice.

Where computing fits in middle school: Middle schools already have a tight schedule and are unlikely to create a new course for computer science. Our approach is to integrate Alice into all disciplines. First, most middle schools have students create projects that might be a poster, an electronic presentation, or a physical model. Alice fits in nicely as another medium for a project in any discipline. An Alice world can tell a story, include interactive questions, or be a game. Middle school students can easily learn enough Alice to create a simple story. With further instruction, Alice can be used for more complicated tasks such as problem solving in science and math. For teachers, Alice can help them animate a topic and create fun quizzes. For example, one of our teachers created a funny story about school safety to show at the start of the year and a science teacher created a story on how hot spot volcanoes are formed, with a mad scientist going underground and a volcano being formed and bursting through the ocean. The paper [9] gives more detail on this approach for integrating Alice into the middle school level.

Where teaching computing fits in high school: Courses in computing found among US high schools include courses on office productivity applications (e.g., word processing, spreadsheets, presentation software), web and graphic design, robotics, and programming at introductory and advanced levels. In recent years, enrollment in Advanced Placement (AP) courses in computing has dropped, leading to elimination of the more advanced of the two AP tests in computer science.

Coupled with this is the absence of any certification program for teachers wishing to teach computing (resulting in computing classes being taught by business teachers, math teachers, as well as by teachers of other disciplines), and an absence of state-level standards for what computing and/or programming courses should entail in many states. (See [12] for greater detail about certification and standards.) There is also the widespread view among state educators that computing belongs as part of Career and Technical Education (CTE). CTE is largely a rebranding of the Vocational Education programs (auto mechanic training, woodworking, home economics, etc.), historically intended for those high school students who were not likely college-bound.

Computing teachers (who themselves have a varied computing background) face a wide range of student ability and interest in their classes. It is thus necessary to make computing an exciting class (as it is an elective course and competes with the other electives in the school), as well as a rigorous one. In addition, the current generation of students has grown up immersed in the media-rich content of the Web and computer games and expects more from a programming course than how to write the "text in, text out" applications of the past. Having to make sure that semicolons, parentheses and curly braces are properly placed only increases their frustration.

Alice has been shown to be an engaging and effective introduction to programming [5]. Running an Alice world produces a 3D animation that allows students to create visually appealing interactive games, simulations and stories, thus providing students the motivation to pursue more upper-level courses in programming and computer science. Alice prepares students for the transition to more advanced programming courses by providing mechanisms that support modular design, the object-orientated paradigm, and concurrent and event-driven programming.

5. FUTURE WORK AND CONCLUSIONS

Building on the success of the first ITEST project, we have proposed a scale-up ITEST grant expanding on the work described in this paper. The goal of this project is to provide state-wide training and support through a partnership with college faculty to middle and high school teachers to enable them to teach appropriate computer science concepts through the use of Alice.

The project will be based in three states which were included in the first ITEST project: Mississippi, North Carolina, and South Carolina with the goal of attracting more students, particularly women and racial minorities, to computing.

At each institution, summer workshops will instruct middle and high school teachers in Alice. Teachers will develop curricular materials for the broader Alice community to be distributed online. In the following academic year, teachers will introduce Alice into their classrooms with the purpose of exciting students about computing, increasing student knowledge of fundamental computing and programming concepts, and growing the number of students who study in a computational field.

In North Carolina and South Carolina, two-week workshops will be held in the summer on college campuses to offer instruction in Alice and to develop curricular materials. A follow-up workshop (NC) and mini-conference (SC) will be held the next summer. Year-long support from college faculty, undergraduate students, or experienced high school teachers will be provided to teacher participants. The North Carolina site will target middle school teachers while the South Carolina site will target high school teachers. The Mississippi site follows a different model due to geographic constraints. The workshop organized by college faculty from Mississippi will train teachers to become master teacher trainers of Alice. Those teachers will then organize and run Alice workshops in their school districts for other teachers.

This project will have a special focus in building community throughout the tri-state region and sharing materials developed with teachers throughout the world. Teachers will present at local, statewide and national conferences. An online repository will be created that will house all curricular and instructional material developed during the pilot ITEST project and all instructional material created during this new phase. Wikis (or similar structures) will be created so teachers will easily communicate among each other. All three sites will run animation fairs where students will be able to display their work. Those fairs have been successful in generating interest among teachers and students.

We hope through our positive experiences with the ITEST grant working with middle and high school teachers in the United States, other faculty will be inspired to reach out within their own communities to encourage broadened participation in computer science. Through the collective efforts of faculty around the world, we can help prevent declining enrollments and retention in computer science and shape young people into computational thinkers.

In conclusion, we hope that faculty members interested in working with middle and high school teachers take advantage of what we have learned during our ITEST project.

6. ACKNOWLEDGMENTS

This material is partially based upon work supported by the National Science Foundation under Grant Numbers 0624654, 0624642, 0624528, 0623808, and 0624479. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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