

Introduction

The U.S. Bureau of Labor Statistics expects a 1.15 million rise in the number of IT jobs over the decade from 2002-2012. The concern with this rapid increase in available job openings is the decreasing number of students choosing to major in computing. According to the Computing Research Association's fall 2000 report, 23,416 students selected computer science or computer engineering as their intended major. In fall, 2004, this number was dramatically down to 15,950. A recent UCLA study has confirmed this decline, showing approximately a 60% drop in the number of students choosing to major in computing [22]. This trend shows no signs of reversal. In fact, further decline is most likely. Data from AP tests over the past 5 years support this scenario. Students taking AP classes in high school often choose to major in the subject in which they have taken an AP course. Despite an increase (from 2001-2004) of 33% of students taking AP tests overall, the number of students taking the AP CS exam was down 9% in the A test, and 20% in the AB test [4]. Additionally, the computer science AP exams maintain the largest gender gap. Minorities continue to be significantly underrepresented in most Information Technology fields, and this is occurring at a time when they are becoming an increasing percentage of the total U.S. population.

Declining student enrollment in computing majors is only half the problem, however. We also have difficulty in retaining those students who do choose to major in computing. On average, at least one-half of college students majoring in computer science withdraw from the field [9]. While attrition occurs throughout the 4 years, the majority of students drop out during the first year [21]. Many researchers have attempted to understand the reasons for this high attrition. Recent studies (such as [8, 10]) have shown students without prior programming experience are at a decided disadvantage in being able to complete a computer science degree. This disagrees with the work of many earlier researchers who observed little correlation between prior programming experience and success in a computer science program. We believe that this shift in explanation may be related to the change by most computing departments from imperative languages (such as C and Pascal) to object-oriented languages (such as C++ and Java). Object-oriented languages require the teaching and learning of all of the material for an imperative language (assignment, decisions, functions, procedures, repetition, arrays, etc.). They then add the concepts of class, object, information hiding, inheritance, and polymorphism. (Though polymorphism is not uniquely an object-oriented concept, most imperative languages do not support it.) Many computing programs also teach event-driven programming, which adds another programming paradigm students must master. As the time spent in college classrooms has not increased, students with *no prior programming experience* are likely to be overwhelmed by the breadth and depth of material. We speculate this leads to the observations by [8, 10]. The volume of concepts and information now required in CS1 (introductory computer science) exacerbates an already troublesome situation. In conclusion, there appear to be two major issues in determining success in the first year of a computer science program. The first is the set of skills (problem solving, logical reasoning, etc.) needed to succeed, and the second is the quantity of programming concepts that students must learn. The challenge is to determine how to concentrate on developing the fundamental skills while covering a more diverse range of material.

Reversing the trend of declining enrollment and the need to improve retention of computing majors are critical issues. A highly-skilled IT workforce is vital to the U.S.'s economic future, our national security, and in maintaining leadership in the world research and development community. Many American companies, led by Microsoft, are lobbying congress for an increase in the H1-B visa limits, attempting to solve the problems of attracting and retaining students in computing by bringing foreign workers to the United States. We believe

that a better solution is to make computing more attractive to American students, so that we can maintain our competitive advantage in information technology through the use of American labor. To do so, we must start in high school (and earlier), with new approaches to attracting students to computing and innovative techniques and methodologies for teaching computer programming.

This proposal addresses the issues of attracting and retaining more students (and especially women and underrepresented minorities) in computing by helping high school teachers learn innovative and effective ways of introducing computing and computer programming. The proposed approach will take advantage of students' high level of interest in media and animation (commonly found in today's students, who have grown up in a multimedia world). Using innovative technology to introduce high school students to programming (an important component of virtually every computing-related major, and generally a major part of first year computing classes), we will not only attract students towards computing but also improve retention by providing the "previous programming experience" that is so important as a predictor for student success in computing in college.

The new technology we propose to teach students is Alice. This technology has been proven successful with college students [13], in summer technology camps, and in the Girl Scouts with middle school students [23]. As such, we believe it will be even more successful with high school students. The following Alice subsection provides background information regarding our successful use of this technology to introduce computing and programming to beginning students.

Alice: *Alice* is a programming environment designed to enable novice programmers to create 3-D virtual worlds, including animated movies and games [15, 16]. Unlike most 3-D programming environments, Alice was designed through an iterative process of studying how novices tried to describe the motions of objects in a 3-D world, and then modifying Alice so that the novices' expectations would be met [17]. In Alice, 3-D models of objects (e.g., people, animals and vehicles) populate a virtual world. Alice makes use of program visualization to allow students to immediately see how their animation programs run, enabling students to easily understand the relationship between the programming statements and constructs and the behavior of their animations. In Alice, students learn the basics of computing, but where the objects of concern are actors and scenes in a virtual world. Alice programs have a strong object-oriented flavor, allowing students to control the appearance and motion of objects, have objects respond to mouse and keyboard input, or do any sort of computation that would normally be done in an introductory programming class. Students learn about objects and aggregation by addressing the component features within objects—lifting an arm, turning a head. Students learn about sequencing and iteration by constructing a series of actions in a scene. Further details about Alice may be found in Appendix A.

Alice has been used successfully in undergraduate classes that draw a diverse range of students into computing [14] and [5, 6, 7]. A set of curricular materials [24] and a text [7] were developed and are being widely used in pre-CS1 courses in colleges (a representative list of colleges using Alice is provided in the Appendix). Details of the results of several studies are provided in the Results of Prior NSF Support section. We have had particular successes with female and African-American students. We have had several pioneering high school teachers who have expressed an interest in working with us to adapt our techniques to the high school level. We plan to enlist several of these high school teachers in working with us to prepare and run workshops in six regional areas around the U.S.

Prior NSF Funding

The work in this proposal builds on the success of a prior innovative research effort, led by PIs Drs. Stephen Cooper and Wanda Dann, in attracting and retaining students in computing at the college level using Alice.

Alice (NSF-0126833, NSF-0302542, and NSF-0339734) has been used successfully as an intervention to attract and retain at-risk students (who are disproportionately female or underrepresented minorities) in computing [5, 6, 7]. At-risk students were defined as those students who had demonstrated less success in math and/or those who had little previous programming experience. A textbook [7] was developed and pilot tested in introductory computer programming courses (pre-CS1) offered at Saint Joseph's University (SJU) and Ithaca College (IC). Additionally, a detailed set of curricular materials [24], including several different curricular models (with complete lecture notes), laboratory exercises, solutions, exams, assignments, sample student projects, and other material, were created. At SJU, the materials were taught prior to CS1, while at IC the materials were taught concurrently with CS1. The primary results of this investigation were:

- 1) The average grade for at-risk students exposed to Alice was a 3.0 GPA in CS1, which is comparable to the grades of students who were at no risk or low risk. The average grade for at-risk students not exposed to Alice was a 1.2 GPA in CS1.
- 2) 88% of at-risk students exposed to Alice enrolled in CS2 after CS1. Only 47% who were not exposed to Alice enrolled in CS2. ($p < .05$, chi-squared)

Further details concerning this investigation are available in [13].

Based on the results of our proof-of-concept study, we were awarded two follow-on grants. The first grant involved the use of Alice with three diverse community colleges to attract and retain majors and to improve the computer literacy course. The second grant involved the running of regional summer workshops to train college faculty in using and teaching with Alice. This past summer, 95 faculty members from 57 schools attended one of our three workshops, and many are teaching with Alice this year. Preliminary results for both of these studies suggest that using Alice has had a statistically significant positive impact on students' understanding of basic programming concepts in both the community college and four-year college setting. Presently, more than 60 colleges, community colleges and universities are using Alice in their curricula.

Dr. Barbara Moskal, our external evaluator, is supported by NSF 0511940, entitled "Collaborative Research: Assessing Concept Knowledge and Attitudes in Introductory Computer Science Courses." This recently-awarded grant is enabling her and her graduate students to create and validate a modern attitudes assessment instrument. Additionally, a graduate student at Georgia Tech, under the direction of Dr. Mark Guzdial, is developing a mastery of object-oriented programming concepts exam, suitable for measuring performance of introductory programming students.

Dr. Susan Rodger has two current NSF grants. The first is NSF-0420343, entitled "ITWF: Collaborative Research: Increasing the Representation of Undergraduate Women and Minorities in Computer Science" (September, 2004 to August, 2008). This grant is part of a collaborative grant with the University of Wisconsin - Madison, University of Wisconsin - Milwaukee, Georgia Tech, Purdue, Rutgers, Loyola University, and Beloit College. The goal of this project is to implement and evaluate a new approach to increasing the number of undergraduate women and minorities in computer science. As part of this grant, Rodger has

formed the Duke Emerging Scholars in Computer Science program. This one-year program for first-year students involves taking three computer science courses: an introductory programming course on animation and virtual worlds (using Alice), a problem solving seminar, and a programming course in Java. By taking these three courses with the same group of students, and solving problems in small groups, the expectation is that students will develop a cohort of friends that will carry them through their other computer science courses if they decide to continue, avoiding the isolation that many current women and minorities have. The program also involves speakers and undergraduate mentors [11]. Rodger's other current NSF grant is NSF DUE-0442513, entitled "An Interactive Approach to Formal Languages and Automata with JFLAP" (May, 2005 to April, 2008). Rodger has developed an instructional software tool called JFLAP that allows students to explore the topics in the formal languages and automata course in a visual and interactive manner. JFLAP is used around the world in 124 countries. This project will develop an innovative way for teaching formal languages and automata (FLA) that uses JFLAP to explore the abstract concepts while learning the formal theory, and evaluate JFLAP's effectiveness through an extensive study. The goal is to show that when using JFLAP in addition to the formal theory that students gain a better and deeper understanding of FLA. This project hopes to show that students are more confident in learning FLA and that instructors can easily adapt these materials to their courses. Teaching materials will be developed mostly at Duke and evaluated at 12 sites [20]. This award builds on another NSF grant Rodger has had for developing JFLAP, including NSF DUE-9752583, entitled, "Visualizing and Animating Proofs in the Mathematical Foundations of Computer Science" (September, 1998 to August, 2002). Rodger developed several additions to tools JFLAP and JAWAA and published several papers on them [1, 3, 12, 18, 19].

Goals

The purpose of this proposed project is to create a collegiate and high school faculty network that will provide the necessary training and support to enable high school teachers to teach fundamental object-oriented programming concepts using improved techniques in simulation and visualization. The Alice 3-D animation software [25] will provide that environment. The approach will take advantage of a high-level of interest in graphics, animation and storytelling, commonly found among students who have grown up in a multimedia world. The major emphasis is the use of visualization to teach and learn a strong core of fundamental programming concepts and problem-solving techniques in an object-oriented, interactive environment.

The *teacher goals* of this project are to:

1. Provide professional development for high school teachers. This will consist of a week-long workshop for the teachers, followed by a one-week curriculum development workshop and a one-week session where the high-school teachers will apply what they have learned in the earlier summer workshops to teach high-school students in special summer sessions.
2. Modify, as appropriate, existing curricular materials, to be appropriate for use in high school. These materials include laboratory exercises, presentation and demonstration notes, and sample student projects and tests.
3. Establish partnerships as a network of teachers in high schools and local colleges in six separate regional areas across the U.S. Professors in the local colleges will host the summer workshops and then provide support for nearby high school teachers during the academic year.
4. Assess the effectiveness of goals 1, 2, and 3.

The *student goals* of this project are to:

5. Excite students about the possibility of study and careers in computing.
6. Increase student knowledge of fundamental computing and programming concepts.
7. Increase the number of students taking an AP course in computer science.
8. Assess the effectiveness of goals 5, 6, and 7.

Project Description

The major focus of this project will be conducting a modified version of the Teacher Engagement for CS (TECS) workshops, as recommended by the Computer Science Teachers Association (CSTA). The CSTA organization was established by the Association of Computing Machinery (ACM) to deal with all issues related to K-12 computing education, and to become “the voice for K-12 computer science education and educators.” [26] We expect that our workshops will be of greatest interest to teachers who will teach courses aimed at meeting the Level 3 standards as proposed by the CSTA (and possibly the Level 2 standards as well). See [27, 28] for more details concerning the national computer science standards. The Level 3 standards are closely matched to a pre-AP computing course (often called the introductory computing course), most commonly taught in grade 11. The Level 2 standards are most appropriate for the computing course taught to 9th/10th grade students. We expect that the participant high-school teachers will be a mixture of computing teachers, math teachers and science teachers.

TECS workshops are designed “to provide quality pedagogically-oriented programs and resources in computer science for teachers of courses described in Levels 2-4 of the model curriculum.” [29] A major focus of TECS workshops is to build a community of college professors and high school teachers. To promote sharing of resources among members of the community, CSTA maintains a rich, centralized, online repository of materials for computer science educators. Materials from TECS workshops (developed by both presenters and participants) will be added to this repository. TECS events should meet the following criteria (paraphrased from the above-mentioned TECS website):

- Provide a program for face-to-face (on-site) learning that addresses the needs of secondary school computer science educators by providing learning experiences in topics chosen from the TECS modules. These modules are based on *A Model Curriculum for K-12 Computer Science: Final Report of the ACM K-12 Task Force Curriculum Committee* [30].
- Assemble a planning group consisting of a university faculty member, a graduate student and an undergraduate student (where possible these should be members of the ACM student chapter) and a local 6-12 computer science educator. The local 6-12 computer science teacher will be required to complete a post-event review to be submitted to CSTA.
- Provide a program that incorporates components that address the engagement of students not traditionally attracted to computer science -- girls and underrepresented groups, the ethical issues prevalent in today's computer-related activities, the wide range of jobs and careers in the field of information technology and computing, problem solving, the development of activities to use in the secondary school classroom, and provide ongoing community support for secondary school computer science educators.

To enable high school teachers to develop the skills and expertise necessary to teach object-oriented programming concepts with the Alice materials, short, intensive summer

workshops will be conducted. The workshops for high school teachers will be modeled on the TECS workshops described above. As part of the dissemination and evaluation efforts (at the collegiate level) of our previous NSF-sponsored studies, we have found that professional development workshops (with later faculty development support) are a crucial element for successful replication of our approaches at other institutions. Many teachers who participated in our collegiate level workshops indicated that the workshops were invaluable for two primary reasons: (1) they were not comfortable with the concepts of objects and object-oriented programming, necessary to effectively teach this new paradigm, and (2) our approach is innovative and thus non-traditional, featuring use of multimedia and graphics (including animation).

Faculty Development Workshop Model: Our summer workshops (in six separate regions) will be hosted by a local college/university (professors, undergraduate students, and graduate students, if applicable), and attended by pairs of teachers from area high schools. (We realize that some of the participating high schools may not have multiple computer science teachers and will only be able to send a single representative, but we believe that, where possible, having at least two teachers from a single school in attendance will enable the teachers to better support each others efforts.) The workshops will run for one entire week (40 hours). It is important to note that faculty in the six local colleges participating in this project have already taught with Alice, so the delegation from each college are already comfortable with the approach. During the weeks following the workshop, high school teachers will spend a week (40 hours) working with the faculty and students at the local college to modify our curricular materials (as needed) for use in (1) a one-week summer special class for high school students, and (2) modules for integrating the approach into a course at their own school. The high school teachers will then run a one-week summer class, with support from the local college. The purpose of this summer class is that high school teachers will be able to gain experience and confidence in teaching with Alice. (Even many college instructors have reported that our novel approach/materials require some practice to gain a sense of security in teaching such a course, and that their comfort level in teaching Alice markedly increased from the first to the second time they taught with Alice.)

Following their summer workshop experience, participating high school teachers will then teach with Alice during the academic year. We will be creating local wikis (a website that allows the easy addition and editing of content) so teachers in the different schools will easily be able to communicate among each other, to help to develop a sense of community. Also, the local college (faculty member(s) and graduate and/or undergraduate students) will serve as a resource to help the high school teachers during the academic year. Graduate/undergraduate students will visit with the teachers in their high schools on a regular basis (typically weekly) during the school year. This will provide on-going support for the high-school teachers throughout the academic year. Teachers will maintain logs, including items such as a syllabus, lesson plans, labs and assignments. Participating graduate/undergraduate students will also maintain logs concerning their interactions with teachers. We will then have follow-up workshops the following summer, to obtain feedback from high school teachers who are using our approach in their courses and to strengthen the sense of community.

Timeline: We plan to offer one workshop in summer, 2006, four workshops in summer, 2007, and one workshop in summer, 2008. The first summer's workshop will serve as a pilot, workshop. While the specific details of the workshops are presented below, they will all follow the same approximate format:

Event	Personnel	Time	Assessment technique (see Evaluation section for greater detail)
Alice professional development workshop	Cooper, Dann, local college faculty and students, high school teachers	Summer week 1 - 40 contact hours	Workshop evaluations
Modification of existing curricular materials workshop	High school teachers, local college faculty	Summer week 2 - 40 contact hours	Peer review of curriculum materials
High school teachers teaching a 1-week summer course for high school students	High school teachers, local college students	Summer week 3 - 40 contact hours	Content assessment Attitude Surveys
Teaching with Alice in high school	High school teachers, with support from local college faculty/students as needed Local college students will be visiting and assisting high school faculty on a regular basis.	Fall or Spring semester – contact hours of Alice instruction vary, but should be several weeks in duration	Interviews and focus groups Content assessments Attitudes surveys Graduate and Undergraduate logs Teacher logs
Follow-up workshop to share experiences in using Alice	Cooper, Dann, Moskal, local college faculty and students, high school teachers	2-3 days in the following summer	End of Project Surveys AP Course and Exam statistics Graduate and Undergraduate logs

While the emphasis of the summer school course the teachers will teach will be on Alice, we expect that there will also be a session concerning careers in information technology. All of the workshops will provide stipends and graduate-level credits for the participating teachers. The basic stipend format is \$500 to attend the one-week Alice professional development workshop, \$500 to attend and participate in the one-week curricular materials modification, \$500 for the running of the one-week summer camp for students, and \$1,000 for incorporating Alice into their class. (There is some variation with respect to this remuneration schedule across the different workshops.) All will also provide classroom follow-ups during the school year. An important aspect of this project is this continued support of high school faculty by the local college faculty and students. This will allow us to very actively track those teachers throughout the year and to provide assistance to them as they work to integrate the program into their existing curricular material.

The above timeline serves as a model. However, different workshops will have some variations, as necessary for local teaching schedules and availability of students/faculty for summer curriculum development and teaching experience. For example, some of the sites will run the curricular materials development workshop immediately after the Alice professional development workshop, others will run the curricular materials workshop a month later, while others will have the teachers do much of the curricular modifications individually (or in pairs),

using the workshop as a place to modify what they have completed. And, there will be several variations in the one week summer course for students. Many of the high school teachers'/administrators' letters of recommendation (appearing in the supplementary materials section) include plans for specific Alice usage and integration into their curricula. Below, a more detailed description of each of the six workshops is provided, along with an explanation of why the specific workshop location and leaders were selected.

Virginia Beach workshop details: The Virginia Beach school district will participate in the pilot summer workshop (summer 2006) and academic year implementation (2006-2007). This school district is a logical location for a pilot implementation and testing ground, as several faculty have already been working to help set up this project. In summer 2005, four Virginia Beach high school teachers (John Harrison, Joanne Rowe, Dan Kooken, and Diane Hirschi) attended an Alice workshop for college faculty at Duke University. Upon return to their schools, they were able to convince the Virginia Beach school district to incorporate an Alice course district-wide (11 high schools in the Virginia Beach area). The Alice usage is expected to be between a semester and 3 quarters. If the course runs for a semester, that will be 45 days at 95 minutes per day or 71.25 hours. Alice will be part of the Computer Programming Course, a course designed for students who have completed Algebra I and Geometry but may not have taken any math beyond Geometry. There will be some portion of the class (usually about 10 - 15%) who has completed Algebra II or Pre-Calculus who is either preparing for AP or IB Computer Science or who is unsure about computer science and is taking this course to find out more.

The Virginia Beach school district consists of 20% African-American students, 5% Hispanic students, and 5% other minority students. Approximately 28% of district students receive free or reduced fare lunches.

Harrison will be leading the effort for Virginia Beach and Cooper (Saint Joseph's University) will provide the collegiate support. Cooper has already been working with representative Virginia Beach teachers during the 2005-2006 academic year towards modifying some of the existing curricular materials (available from www.aliceprogramming.net) for use in high school. The Alice professional development workshop will be used to train teachers from the other seven high schools in the district. Cooper and Harrison will co-run the curriculum development workshop. Cooper will travel to team meetings at least once a month during the 2006-2007 academic year, and a representative group of high school teachers will travel to Philadelphia to observe Alice being taught at SJU.

Lessons learned from evaluating the pilot at Virginia Beach will be used in a formative manner to prepare for remaining workshops in the project. And the materials developed by the Virginia Beach teachers as part of the curriculum development workshop (stored both on the CSTA website as well as on www.aliceprogramming.net) will be used as the basis for the later curriculum development workshops at the other sites.

California workshop details: This workshop is planned for summer 2007. We expect that this workshop will closely follow the above-mentioned model. This workshop is expected to attract teachers primarily from the San Francisco and San Jose unified school districts. The San Francisco school district has approximately 19,000 students in high school, with 9% of its students identified as White. 37% of the students are Chinese, 20% are Hispanic, 13% African-American, and approximately 20% other minorities. Over 25% of all students are eligible for free or reduced lunches. Of the teachers (in K-12), 45% are white, 11% are Chinese, 8% Hispanic, and 6% are African-American [35]. The demographics of the San Jose school district are slightly different than the San Francisco school district. The 7 high schools are comprised of 31% White,

49% Hispanic, 13% Asian, 3% African-American, and 4% other minority. 30% of its students have limited English proficiency (and is a specifically challenging problem among the Hispanic students) [36].

Colorado workshop details: This workshop is planned for summer 2007. The Colorado School of Mines (CSM) is the second oldest and one of the largest colleges of mineral engineering and applied science in the country. CSM offers more science content-based teacher (K-12) recertification courses than any other institution in Colorado through the Office of Special Programs and Continuing Education (SPACE). CSM, as a direct result of SPACE, has been nationally recognized as a leader in both teacher training and K-12 curriculum design.

As part of this overall project, we propose a two-week workshop to be held in June for high school teachers through the SPACE Office. The SPACE Office is responsible for advertising, recruiting, providing classroom space and computers, and preparing transcripts to verify recertification credit. Dr. Catherine Skokan will be responsible for the overall functioning of the Colorado workshop and academic year activities.

During the first week of the proposed CSM workshop, teachers will receive training on Alice (presented by Skokan, Cooper, and Dann). In the second week, teachers will incorporate this training into lesson plans. These lesson plans will then be tested with a group of high school students in August prior to the start of the regular academic year. Follow-up biweekly classroom visits by a graduate student will help the teachers to carry out the lesson plans as well as help in the classroom as a resource for the students. Teachers and students for this project will be drawn from the Denver Public School System (DPS). DPS is an urban school system that is culturally and economically diverse, serving over 73,000 students. The student population is approximately 55% Hispanic, 20% African American, 1% American Indian, 3% Asian, and 21% Caucasian (Facts and Figures, DPS, 2006). Approximately 20% of the students speak English as a second language, and 63% of the students qualify for free or reduced fare lunch. The students are served by over 4,000 teachers [32].

Because the location of this workshop is close to the external evaluator, it is expected to serve as the site of the most in-depth evaluation for our project. The overall details are described below, in the Evaluation and Assessment section.

North Carolina workshop details: This workshop is planned for summer 2007, hosted by Susan Rodger at Duke University. Rodger has five years experience using this approach in an introductory programming course at Duke. We propose a two-week workshop on Alice for high school teachers at Duke. The first week will be co-led by Cooper, Dann, and Rodger. The second week (where the modifications to curricular materials will occur) will be led by Rodger. The high school participants will be ten regional high school or middle school teachers, from the Raleigh, Durham, Chapel Hill and Cary areas. Six additional high school teachers will be included from outside the region. Duke undergraduates will be involved in several ways, including assisting during the two week workshop, and helping to develop materials, assisting in the local summer programs for high school students, and creating and maintaining an online resource page in support of the teachers. The teachers will be required to send us their syllabus and materials for both summer programs and integration into the academic year. We also anticipate that some of the high school teachers will teach a unit of Alice the following summer in the Duke TIP program (see [33] for more details about this program), a three-week residence program for talented high school students.

South Carolina workshop details: This workshop is planned for summer 2007, as a cooperative effort by RoxAnn Stalvey (College of Charleston) and Madeleine Schep (Columbia College). The workshop will be offered to high school teachers who teach in schools located near the College of Charleston or Columbia College. The format of the workshop and academic year support will follow the model outlined previously. Stalvey and Schep will build on their experience with Columbia College's annual Math Day for Girls and the College of Charleston's annual programming competition. The Math Day for Girls enables high school and middle school girls to participate in a number of contests and attend workshops. During this day, there is a workshop for accompanying teachers. During the most recent Math Day, Stalvey and Schep presented an Alice workshop for the teachers. In February, Schep and Stalvey will present a second workshop to high school teachers during the College of Charleston programming competition. This workshop is designed to give teachers an opportunity to write simple Alice programs and to view more advanced samples. (See the supplementary materials section for a flyer describing their workshop.) Stalvey and Schep's contacts with high school teachers through these events provide them a unique opportunity for attracting teachers to participate in the proposed workshop in the South Carolina region.

Mississippi workshop details: This workshop is planned for the summer of 2008. At the University of Mississippi, outreach efforts to both students and teachers are already in place, and in this effort need only to be expanded to increase the success of this program. Maxine Woolsey, the leader for this workshop, has been leading this effort. We propose to build on the existing Engineering and Space Grant programs to work with teachers of computing in high schools by providing an opportunity to actively track those teachers throughout the year and to provide assistance to them as they work to integrate the new approach into their existing curricular material.

At the University of Mississippi Engineering School, a new course, Engineering 100 has been developed and delivered in multiple ways. In its pilot year last year, the course was delivered both synchronously and asynchronously to five locations throughout Northern Mississippi. More than 60 students participated in the program along with their classroom teachers. In this program Alice was used to introduce computer programming to the high school students and first year potential engineering students. The project met with great success and will be repeated in an expanded program in summer 2006. Students and teachers will actually be brought to campus in the summer. Bringing the teachers to campus will only increase the effectiveness of the program. The Engineering school is very active in summer workshops for teachers and has successfully, to date, taught more than fifty teachers in summer Alice programs. For the next year Engineering 100 will partner with Mississippi Public Broadcasting to offer the program to all high schools with distance learning facilities within the State. To date, 30% of the schools have agreed to participate. This program provides us with an immediate, existing and committed group of teachers who are working hard to introduce their high school students to engineering careers in general, and to Alice programming in particular.

We expect that this workshop will be similar in approach (though significantly longer in duration) to the work being done by The Mississippi Space Grant Consortium. The Consortium is directly involved in teacher training and opportunity awareness programs. In the winter of each year, the Consortium brings between fifty and seventy-five middle school teachers to campus for an extended weekend program. For the past two years the University of Mississippi has used Alice as one of the sessions provided to the teachers. In this session each teacher is presented with a CD and two-three hours of instruction to help them get started. These teachers have then invited us into their school systems to "Spread the Word" to their colleagues. At the

most recent workshop the teachers were especially interested in using Alice in a “writing through the curriculum” program where students first write stories and then use the software to animate the stories that they had written. Two of those schools have already initiated efforts with the University of Mississippi to get that program started.

Project management: In this collaborative project, Cooper will be the lead PI for the project, and, in this role, will oversee the implementation of all project activities. Dann and Cooper will co-present all of the Alice professional development workshops. Dann will act as a curriculum and instructional materials development consultant for all regional workshops. The curriculum development workshops will be run by Harrison and Cooper (Virginia Beach, VA), Triefenbach and Lewis (San Jose, CA), Skokan (Denver, CO), Rodger (Raleigh-Durham, NC), Stalvey and Schep (Charleston, SC), and Woolsey and Lawhead (Oxford, MS). Moskal will be responsible for evaluation of the project. Barbara Conover will serve as the project manager for the grant, and will help to coordinate all of the workshops, and help with the communication involving all teachers and students.

Experience/Capability of Personnel

We believe that we are uniquely qualified to run this investigation. Drs. Cooper and Dann have been developing Alice instructional materials for the past 7 years, and have run more than a dozen Alice professional development workshops for high school and/or college teachers. Cooper is on the CSTA’s subcommittee for developing the Level 3 national computing standards. He is also involved in creating a local Philadelphia-area chapter of the CSTA. Cooper has been running Pathways to Careers in Mathematics And Computer Science (PACMACS) for the past 5 years. PACMACS enables 10 African-American students from (non-magnet) Philadelphia public high schools per semester to take a programming class with Alice (as well as a mathematics class) at SJU, as well as receiving mentoring, and other preparations for college. PACMACS has been quite successful, with many of its graduates either currently majoring in or graduated with college degrees in CS and/or engineering.

Dann has extensive experience as a professor and researcher in visualization of programs and programming languages. Dann is a curriculum development expert, having an MAT in teaching from the highly respected department of education at Colgate University. She has experience as a high school teacher and department chair and is permanently certified for teaching math and science in secondary schools. She worked as a consultant with the NY State Board of Regents on curriculum and testing. After earning a Ph.D. in CS, Dann is now an associate professor at IC and acts as a curriculum consultant and curriculum committee member. Dann has experience in working with minority students using Alice. She is currently working with the CS and Hawaiian Studies faculty at the University of Hawaii to create a combined Alice and Hawaiian Studies course for native Hawaiian college students. Our Alice textbook [7] is being widely used at the college level. (See the appendix for a list of colleges using our text this past fall.)

Cooper and Dann have experience in managing large grants. Our ATE community college grant has involved seven schools, nearly 100 teachers, and over 3000 students. Our other follow-on grant had representatives from 57 schools attending a summer workshop, with nearly two dozen participating in a study we are running this academic year.

Dr. Barbara Moskal (Colorado School of Mines) will again serve as our external evaluator. Moskal is a national expert in evaluation (with experience in K-12 evaluation), and has served as our evaluator on several previous Alice grants.

We are planning to run six summer Alice TECS workshops over the course of the three years. The first year's workshop will be held in Virginia Beach. John Harrison will lead the effort. Harrison is recognized as the leader of the curriculum committee for the Virginia Beach school district. He has worked hard to get the school district to place Alice into the curriculum.

During the second year, four summer workshops will be offered: in San Jose, Denver, Raleigh-Durham, and in Charleston, SC. The San Jose workshop will be co-run by Dan Lewis and Fred Triefenbach. Both Dan Lewis (Santa Clara University, SCU) and Fred Triefenbach (The Harker School) are strong co-leaders for this site. Lewis created the computer engineering department at SCU, and has served as its chair for nearly 20 years. Lewis has prior industry experience and contacts, and has been able to raise industry money to run a CSTA Java Engagement for Teacher Training (JETT) [31] summer workshop for in 2005, attended by 29 high school teachers from northern and southern California, and a TECS summer workshop for high school teachers this upcoming summer which will include a unit on Alice. He has been teaching with Alice this past year in his classes. He serves on the advisory board for the National Youth Leadership Forum on Technology. He also has experience with the teaching of female and minority students, as the freshman class at Santa Clara University has 32% minority students, and is 56% female [34]. Triefenbach has been teaching computer science at The Harker School (a private high school) for the past 7 years, currently serving as the department chair. Prior to this, he had significant IT industry experience. He attended one of the Alice workshops in summer, 2005, and has been teaching with Alice in his own classes during the past year.

The Denver workshop will be led by Catherine Skokan at the Colorado School of Mines. Dr. Skokan, an associate professor in the Division of Engineering with an electrical engineering specialty, has been active in higher education/K-12 connections, especially in science, engineering, and technology applications. She has organized and presented two to three workshops per year over the last five years. As a result of some of these workshops, many middle school teachers are presently using Alice in their classrooms. She has written classroom curriculum and offered workshops to K-12 teachers as part of projects funded by agencies such as the National Science Foundation, the Colorado Department of Education, and the Colorado Commission on Higher Education.

The Raleigh-Durham workshops will be led by Susan Rodger. Rodger has been teaching introductory computer science for seventeen years. She has been teaching Alice for five years, at first as a short module in another course, and now for two semesters as a full course. Rodger has also run several computer science workshops for high school students and for high school teachers. In 2005 she was a co-leader with Cooper and Dann in a 2-day Alice workshop at Duke, and will be co-leader of a much larger 3-day Alice workshop at Duke in June 2006.

The Charleston, SC, workshops will be co-led by RoxAnn Stalvey and Madeleine Schep. Schep and Stalvey attended one of the collegiate Alice workshops in summer 2005. At Columbia College, Schep integrated a unit of Alice at the beginning of the CS1 class. Topics covered included control structures and object-oriented concepts. She has also taught a longer unit of Alice in a CS0 course. At the College of Charleston, Stalvey has taught Computer Literacy and introduced programming to the general college population using Alice. The following semester, Spring 2006, Stalvey began teaching a new full-semester course in Alice. Both Stalvey and Schep have experience in running computer workshops for middle-school and high school teachers. Many of the teachers who have attended their workshops are especially excited about the possibility of attending this one.

During the third year, we will offer a workshop in Oxford, led by Maxine Woolsey and assisted by Pam Lawhead. Woolsey is an engineering outreach expert, and serves in this capacity at the University of Mississippi. Lawhead has experience in teaching with Alice, both in her own

classes as well as during summer workshops to high school and middle school teachers. Woolsey attended one of our Alice workshops in summer, 2005, while Lawhead co-ran that workshop at the University of Mississippi.

These six regions have been selected because the associated high school districts tend to have large numbers of economically disadvantaged and/or minority students. Each of these areas has high school teachers who have expressed interest in our materials/approach, and each of these colleges has faculty who have taught with Alice and have expressed a dedication to working with high schools.

Evaluation and Assessment

The summer workshops will involve approximately 90 high school (and some middle school) teachers. If each teacher teaches two sections of 25 students in a course using Alice during the school year, then approximately 4500 students will be impacted. If each pair of teachers teaches a group of 20 students over the summer (in preparation for teaching during the school year), that will be an additional 900 students, leading to a total impact of 5400 students.

Dr. Barbara Moskal, an expert in project assessment (see biographical sketch), will oversee the efforts of external evaluation team from the Colorado School of Mines Mathematical and Computer Sciences department. This team will consist of graduate students who are studying the use of quantitative and qualitative methods in the evaluation of educational projects. As students and teachers will participate in this project, all appropriate human subject procedures will be followed throughout this investigation. This includes receiving approval from Internal Review Boards, obtaining all necessary written consents, and the maintenance of strict confidentiality throughout the study. The sections that follow describe the formative and summative assessment methods that will be used throughout this project. The implementation of this plan supports the attainment of project goals 4 and 8 (assessing the effectiveness of goals 1, 2, 3, 5, 6, and 7).

Formative: Qualitative research techniques will be used for formative evaluation purposes. Qualitative techniques have the advantage of providing detailed descriptive information and this type of information is useful for project improvement purposes.

Workshop evaluations: Approximately every two days throughout the workshops, the participating teachers will be asked to provide feedback to the workshops instructors. Specifically, they will be asked to provide questions about the workshop content and suggestions for improving the workshops. This feedback will be used immediately by the instructors for improving the next days' lessons. This feedback will also be reviewed before the next offering of the workshop is implemented. A similar technique will be used with the special summer session for high school students. In this case, it will be the high school students that provide the feedback and the teachers will work with the investigators to improve the next day of instruction. This formative evaluation technique is designed for the improvement of project goal 1.

Peer Review of Curriculum Materials. At least three external experts in the field of computer science education and three high school computer science teachers will review all modified materials, and revisions will be made based on their recommendations. Specific individuals to perform these reviews will be determined. It is expected that the college reviewers will come from the SIGCSE community and the high school reviewers from the CSTA community. Peer review is a widely accepted technique for examining the content, construct and criterion validity of instructional materials [2]. This method is designed for the improvement of goal 2.

Interviews and Focus Groups. Randomly selected students in pilot classrooms will be interviewed. Interviews will focus upon their experiences with the materials and how these experiences have influenced their future educational goals. Students not selected for individual interviews will participate in student focus group activities. Questions asked in the focus groups will be the same as those asked during the individual interviews. The focus group activity will ensure every student has an opportunity to express his/her viewpoint. The evaluator, or her graduate student, will need to travel to the site to perform this activity. This will provide further feedback for the improvement of project goals 5 and 6.

Participating teachers and college faculty will also be interviewed. The focus of this interview will be upon the strength of the partnership that has been formed between the two cooperating groups and is designed to provide formative feedback with respect to goal 3.

Classroom Observations. Classroom observations will also be completed in each of the participating schools. The purpose of these observations will be to determine the extent to which the workshop materials are being used in the classroom. Based on what is observed, adjustments will be made to better reach project goals 1, 2 and 3.

Review of College Student Logs. At the end of each week throughout the academic year, the participating college students will submit a log of their activities. This will both document their classroom activities as well as provide the evaluator with feedback concerning teacher questions. The evaluator will share any concerns that emerge through these logs with the project investigators, who will complete follow-ups. This will contribute to the attainment of goals 1, 2, and 3.

Summative: The summative evaluation will use a combination of quantitative and qualitative research techniques to support the statistical analysis of our efforts. While we intend to keep track of the number of teachers and students impacted as a result of our workshops, we are also interested in determining the effect of the resulting courses on the high school students themselves. A survey will be given to determine the students' background in mathematics, computers and computer science. The data collected by this readiness survey will be used to examine relationships between mathematics and computer science preparedness, student performances and rates of attrition.

Content Assessment. The participating teachers will complete a content assessment at the beginning of the summer workshops (pretest). The instrument that will be used is currently being developed as part of another NSF funded project (as described above in the prior NSF support section). They will then complete a posttest after they have completed a full year of instruction using the revised computer science curriculum. Statistical comparisons will be made using a paired t-test between their pre and posttest scores. This will directly assess project goal 1.

Both students in the summer special program and students in the participating teachers' classrooms will also participate in a pre and post content assessment. The first group will complete this instrument immediately before and immediately after the summer program. The second group will complete this instrument immediately before and immediately after their semester or one year computer science course. Paired t-tests will be used to evaluate the impact of these interventions. Furthermore, in the participating classrooms, statistical comparisons will be made between female and male performances and among the various ethnic groups. This will assess project goal 6.

Attitudes Survey. An attitudes survey will also be administered in a pre and post format to students in the special summer session and to the students in the participating classroom. This instrument will be used to determine whether student attitudes toward computer science have improved as a result of project participation. The instrument that will be used is currently being

developed as part of another NSF funded project (as described above in the prior NSF support section). This will directly assess project goal 5.

Teacher Logs. Teachers will be asked to maintain a log, noting their experiences with respect to mastering of the content, the curricular materials, and their involvement with the local college. These logs will be examined by the evaluation team using a common scoring rubric to determine the extent to which the project goals 2 and 3 have been reached.

End of Project Surveys. Participating teachers and college faculty will be asked to complete an end of project survey. This survey will specifically be designed to measure project goals 2 and 3. Information acquired from this survey will be summarized using descriptive statistics.

AP Exam Statistics. Baseline data will be collected at each participating school to determine the number of students that participate in the AP exam for computer science. After the intervention, comparisons will be made using a Chi Square analysis of the proportion of students that completed the exam before and after the intervention. These values will be examined for statistically significant change. Furthermore, comparisons will be made between male and female participation and participation among the various minority groups. This will directly assess project goal 7.

Dissemination

Clearly, the workshops proposed for this project are in and of themselves a form of dissemination. We will collect the teacher logs of curricular materials and create a repository of materials that will be made available via the internet. We currently use the website [24] as a repository of curricular materials and we expect to add the high school materials to this website. We intend to also place the high school curricular materials in the CSTA's repository. All materials will be freely available, but many will be placed in a password-protected area to limit access to teachers.

We have an established record of presentations at collegiate, national and international conferences for computer science, such as SIGCSE (the Special Interest Group on Computer Science Education, the US national computer science educator's conference), ITiCSE (Innovation and Technology in Computer Science Education, the European version of SIGCSE), and ISECON (the Information Systems Educators CONFERENCE, the information systems national education conference). Dann has been invited to present a workshop at the AP College Board national conference, summer 2006. We expect to present papers and offer workshops at these conferences and at NECC and ISTE events regarding our work and evaluative results for the proposed project. We also publish a monthly Alice e-newsletter to nearly 300 subscribers (approximately 30 of whom teach in high school). We expect to add the workshop participants to our subscriber's list.

Our current Alice text [7] is considered to be a bestseller (in terms of academic sales). We have been contacted by a number of authors of introductory computer science and/or computer literacy texts, especially those targeting a high school audience, about creating a new version of their book with a significant part devoted to Alice. During this year's SIGCSE conference in March, we will be having discussions with five authors of various introductory computing texts to identify who will be the best potential partner. Our publisher, Prentice-Hall, has also inquired regarding our willingness to write an Alice text specifically for the high school audience. (A letter of support from them is included.) We expect that we will use the materials that will be developed during this grant as a framework for developing such a book for use by high school teachers and students.