Berkeley Foundation for Opportunities in Information Technology (BFOIT): A Decade of Broadening Participation

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The Berkeley Foundation for Opportunities in Information Technology is a decade-old endeavor to expose pre-college young women and underrepresented racial and ethnic minorities to the fields of computer science and engineering, and prepare them for rigorous, university-level study. We have served over one hundred fifty students, and graduated over sixty-five seniors who have gone on to attend some of the top institutions in the country. Some of the lessons we have learned include the importance of sustained funding to support a continuing year-round program, world-class leaders and resources, and family and alumni involvement. In this paper, we share the inner workings of our program, from its foundation during the dot-com heyday through today, in hopes that our best practices can be useful to others working toward the goal of broadening participation.

Categories and Subject Descriptors: K.3.2 **[Computers and Education]**: Computer and Information Science Education – *computer science education*.

General Terms: Experimentation and Human Factors

Additional Key Words and Phrases: Broadening participation, outreach, computing education pipeline, summer camps, introductory programming courses, CS0, Scratch

1. INTRODUCTION

The Berkeley Foundation for Opportunities in Information Technology (BFOIT), a project of the International Computer Science Institute (ICSI), has been working to broaden participation in computing and engineering for more than a decade. It currently has two full-scale programs, one for middle school students: Science for Youth (SCI-FY), and one for high school students: Information Technology Leadership Program (ITLP). A third fledgling program for elementary students, Early Techies (ET), was initiated in the summer of 2010. These programs are aimed at pre-college young women and underrepresented racial and ethnic minorities with the goal of providing them with knowledge, resources, practical programming skills and guidance in their pursuit of higher education and careers in computing and engineering fields.

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BFOIT was initiated in 1999 by University of California Berkeley's (UCB) Electrical Engineering and Computer Science (EECS) Industrial Advisory Board in response to Proposition 209, which prohibited public institutions from giving preferential treatment based on race, sex or ethnicity. It was established as an external organization (i.e., not affiliated with UCB), to comply with the terms of the proposition. Eventually it became the outreach project of International Computer Science (ICSI), where it now resides. Through BFOIT, we have been able to continue our goals of recruiting and preparing underrepresented students for challenging computing and engineering careers.

We started out teaching programming to 25 local high school students for a single week in the summer. We have expanded it to two year-round programs culminating in two-week summer institutes, teaching 25 middle school and 25 high school students computer science, engineering and leadership development. The pilot elementary program, Early Techies (ET), began with ten 3rd-5th graders and their parents, and continued over four consecutive Saturday programs in May and June 2010. These *free* programs work in concert to form a three-stage pipeline serving 60 (often repeating) students annually, but we seek to have an even greater impact by further expanding the size and reach of our current programs.

Since our founding a decade ago, we have served 153 students, and graduated 65 seniors who have attended some of the top universities in the country, including: UC Berkeley, Massachusetts Institute of Technology, Carnegie Mellon, Harvard University, Columbia University, Brown University, University of Southern California, Boston University, Santa Clara University, UC Davis, UC Santa Cruz, University of Pittsburgh, Mt. Holyoke College and the University of Georgia. In this paper, we will discuss our programs in more detail, share testimonials from our graduates and their parents, reflect on the lessons we have learned and describe our future plans.

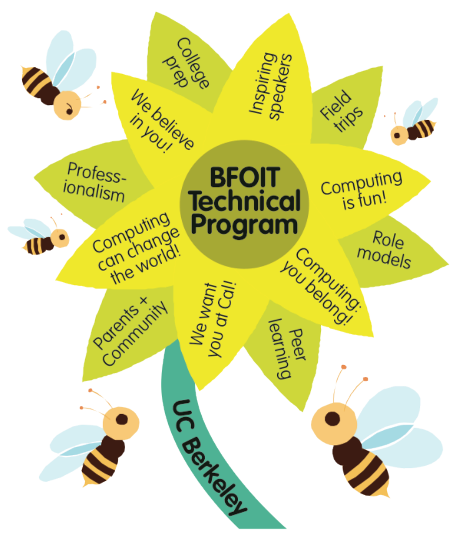

Fig. 1. An illustration to symbolize the essence of BFOIT; rooted at UC Berkeley, the BFOIT "flower" draws student "bees" to its technical program, who then are exposed to its holistic "petals" in the process. The bees bring the knowledge "pollen" back their school "hive" and tell others of this great flower, and more return.

2. RELATED K-12 BROADENING PARTICIPATION EFFORTS

Dozens of programs have been developed over the last three decades to address the national concern about increasing participation of girls and minority students in STEM fields. These K-12 programs have been initiated by colleges and universities, local departments of education, by public science museums, by national groups such as the Girl Scouts of America, by professional societies like the Society of Women Engineers, by national laboratories, e.g., Lawrence Berkeley National Lab, NSF Science and Technology Centers, and IT corporations such as Microsoft, Intel and Google. Both industry and government fund the programs. The National Academy of Engineering, SWE, IEEE, Engineering Education Center, and many other professional societies have developed visually exciting websites for girls interested in engineering and science. The National Coalition for Women in Technology (NCWIT) has compiled on their website an extremely useful resource list of "Promising Practices," at all levels, focusing especially on computing. In the K-12 domain, NCWIT documents many of the most effective pre-college programs that promote and advance computer science [NCWIT 2010].

Since the 1980's, the National Science Foundation has played a very key role in funding STEM intervention programs for pre-college women and minority students and their teachers. The early programs encompassed science, technology and engineering fields but did not focus particularly on computer science. The current CISE Directorate at NSF, has sponsored Broadening Participation in Computing (BPC) grants for computer science intervention programs at all levels, under the dynamic leadership of Program Director Jan Cuny. All BPC programs must have the capacity for widespread impact and adoption. Undeniably, many outreach programs are motivated by NSF's grant evaluation criterion of "broader impacts"; that is, how well does the proposed grant activity broaden the participation of underrepresented groups? [NSF 2009].

As background to our discussion of BFOIT, we cite some examples of well-known existing programs, including three in which Berkeley graduate students have volunteered to lead workshops and serve as role models. These programs and services take a variety of forms that include research, one day conferences, summer computer camps, after school programs, recognition programs to reward high school students who excel in computer science, mentoring programs, teacher training, regional collaborations among schools and agencies, and the development of new computer curricula to engage students and encourage them to pursue computing.

Voluminous research has contributed to our understanding of the causes for racial and gender disparity in computer science participation. Research has also helped us appreciate the experience of women and minorities in the field of computing, and this has informed our interventions. Some major contributions to our knowledge can be found in the ACM Report on The Status of Women in Computer Science, which contained a key paper "Becoming a Computer Scientist," A. Pearl, et al, [1990], and the 2002 ACM SIGCSE Bulletin Special Issue Women in Computing, containing a reprint of Tracy Camp's "The Incredible Shrinking Pipeline" [1997]. Jane Margolis and Alan Fisher published a pioneering longitudinal study of the differing experiences of men and women undergraduates in computer science at CMU [2002]. Relevant to BFOIT is Dr. Margolis' recent book [2008], in which she traces the experiences of African American and Hispanic students in three Los Angeles high schools. Margolis concludes that the race gap in computer science parallels a host of disadvantages experienced by these students. As a response to this research, Dr. Margolis is working with two colleagues to develop a new and compelling computer science curriculum, presently being piloted in the Los Angeles Unified School District [Goode 2008].

Professor Lenore Blum, then at Mills College, and Nancy Kreinberg, Lawrence Hall of Science, both Math Science Network volunteers, developed the first *Expanding Your Horizons* (EYH) conferences in 1976; EYH now occurs throughout the globe and reaches thousands of girls each year [EYH 2010]. These one-day conferences attract an average of 500 girls, who meet role models and participate in hands-on workshops. Berkeley women students from their grad organization WICSE have led animation workshops for middle-school girls using the Scratch programming environment [WICSE 2010]. The conferences were evaluated to assess their impact; the NSF study found that girls are affected by a one day intervention: the survey respondents enrolled in more optional math classes and took more career-related actions than students who did not attend the EYH conferences.

The National Girls Collaborative Project (NGCP) exemplifies a model for a robust national network of programs and regional leadership teams, which reach 2500 STEM organizations serving girls from 28 states [NGCP 2010]. For example, the NGCP leverages best practices to share resources, evaluation, strategies designed to engage girls in STEM. The programs vary in focus areas and populations served and include higher education institutions, community-based organizations, private non-profits, but all work to leverage resources and increase gender equity in STEM fields [Marra et al. 2008].

Aspirations in Computing is a recognition program in which the computer-related achievements of high school girls are celebrated in their local communities [Aspirations 2010]. Teachers nominate the students, who are honored at an event that gives them visibility and reinforces their computing aspirations. The awardees must have demonstrated outstanding aptitude and interest in IT and computing, shown leadership ability, and plans to attend college.

Funded by NSF's BPC Program, *Georgia Computes!* is an example of a comprehensive university-sponsored program, led by faculty and graduate students from the Georgia Tech College of Computing. It aims to improve computing education throughout the state at all levels with a special focus on developing and implementing models for recruiting, mentoring and retaining students from underrepresented communities. Diverse mentors, such as high school students and disabled undergraduate students, expand the image of who can do computing. Other elements include weekend computing workshops for Girl Scouts; after-school computing workshops with Cool Girls, Boys and Girls Club and the YWCA; summer camps for 4^{th} through 12^{th} grade students at Georgia Tech and eight other colleges and universities; and computing workshops for high school teachers to engage K-12 students. The Georgia Tech Computing Camp attracts high school girls in the summer for several days of introduction to programming and exposure to role models. They report that this program has exponentially increased the number of Girl Scouts participating in workshops, created eight regional summer computing camps, doubled the number of schools offering Advanced Placement Computer Science classes, doubled the number of Hispanic students taking the AP exam and has influenced a quarter of the computing programs in the University System of Georgia [Bruckman et al. 2008].

Techbridge, hosted by Chabot Space & Science Center in Oakland, CA, offers programs to encourage underserved girls in technology, science and engineering, reaching thousands of girls in the local community and nationwide [Techbridge 2010]. Through after-school and summer programs, outreach events, and training sessions for teachers, parents and role models, they build a strong community of support.

LEAD Engineering is a program that introduces engineering to students of color who have demonstrated both academic strength and leadership [LEAD 2010]. Begun in 2008, they hold summer institutes for sophomores and juniors in all fields of engineering, including electrical and computer engineering. Students reside on campuses for a three-week period during the Summer Engineering Institute (SEI). LEAD Engineering was held on the UC Berkeley campus in summer 2009, and works in partnership with corporations as well as other universities like the University of Virginia.

National organizations, like Girls, Inc. and Girl Scouts, collaborate with industry for technical programs. In 2008 Google launched a teacher education program called *CS4HS*, which was piloted at six universities, including MIT and Carnegie Mellon University [Blum et al. 2008]. The program, which expanded in 2010 to 20 universities (including UC Berkeley), brings high school teachers together for a summer workshop [CS4HS 2010]. The goals are to inspire them about computational thinking, offer some instructional tools for their classroom teaching, and provide opportunities to meet local colleagues. Universities develop the curricula and maintain contact with the teachers after the workshop. We believe there are real connections between CS4HS and BFOIT.

3. HISTORY OF BFOIT

3.1 UC Berkeley's First CS Diversity Program

Faculty in UC Berkeley's computer science (CS) division worked proactively for fifteen years in the 1980's and 90's to bring more women and minorities into the graduate pipeline through the CS Re-entry Program. The approach was to tap talented, post-baccalaureate women and minorities with undergraduate degrees in fields other than CS, and accelerate their entry to graduate study in CS. Students came with degrees as diverse as Classics and theater design. This grassroots program represented the major outreach efforts of the faculty during the period 1983-1998. During that period, 156 women and minorities were admitted into the compressed program of CS coursework to prepare them for competitive admission to graduate programs in EECS. The program included regular upper-division coursework, faculty advising, graduate school admissions coaching, and academic support, and students spent at least two years in the program. When the program was phased out in 1998, at least fourteen women had gained PhDs, and more than forty-five had attained Master's degrees [Humphreys and Spertus 2002]. The quantifiable results of Berkeley's Re-entry Program are one metric; more subtle and lasting effects, though, include a greater sensitivity to women students, and an appreciation of the talents of older students and those from varied disciplines.

The passage of Proposition 209 by voters in California in 1996 greatly constrained and continues to constrain universities from providing the educational benefits of such a program based on gender and ethnicity. At the same time, the members of the UC Berkeley EECS Industrial Advisory Committee at their annual meeting strongly urged the faculty to increase efforts to bring more women and minority students into the major. By the mid-1990's, enrollments in CS were dropping significantly. Some CS faculty felt the re-entry program was not producing results rapidly enough to change the face of graduate enrollment, given the time needed to earn graduate degrees. A major shift occurred then, prompted by outspoken CS advisory board members frustrated by the lack of progress, when the decision was made to change the outreach focus from diversifying the graduate pipeline to engaging the pre-college audience. Thus, BFOIT was born, with the primary goal of reaching out to high school students; the SCI-FY middle school program was added later. Nevertheless, the effects of the CS Re-entry Program have had a lasting effect on the culture of the computing community at Berkeley.

In addition to BFOIT, EECS faculty and students give their time and technical experience to many outreach programs. There are "official" outreach programs [EECS

2010], but individually and without fanfare, our EECS graduate students teach math at San Quentin Prison, tutor students in local public schools, serve as mentors, and make presentations on engineering at middle and high schools, as do the EECS faculty.

3.2 Evolution and Development

Over the last ten years, a natural progression in the program's development has occurred. Initially, the ITLP program lasted one week in August, with applications due the prior spring, and very little follow-up afterwards. After two years, we expanded to two weeks and began a process of rolling, year-round recruiting and admission. This allowed us to refine our entrance criteria, and get to know our students and their academic-year faculty much better due to repeat student participation. In 2004, a few parents begged us to allow their 8^{th} grade girls to participate in ITLP. We were very skeptical, because we assumed there would be cognitive and social issues. We decided to give it a try, after we realized the computing prerequisite was only algebra, and not higher-order mathematics. The three 8^{th} graders did so well, we started having conversations about the creation of a middle school program, and SCI-FY was born in 2005. For the summer institutes, we share a classroom and computer lab, with each group occupying one of the rooms for the morning period, eating together and swapping after lunch. We later saw the need to create a more comprehensive program for our students (as well as help us keep connected), so we added a year-round component, described in Section 7.6.

3.3 Funding

BFOIT was founded on the premise that it would be free for all students, with admission based solely on merit and initiative, since we did not want cost to be an issue for anyone (and did not wish to initiate a complex scholarship mechanism). Thus, we derive all revenue from external sources. Our funding model has evolved, from individual donations (often ICSI staff and CS faculty) and distributed corporate grants to the current source, a single local foundation interested in supporting STEM in early and secondary education. Thanks to regular donations of volunteer time and meeting space, we have very low overhead, and take great pride with how far we are able to stretch our annual $50k budget. Most of the money goes to our staff (salary for the part-time Executive Director and part-time Coordinators, honoraria for the program leads), with the remainder covering any costs associated with the summer institute (equipment, field trips, food, t-shirts, etc.).

3.4 Overarching Goals

From the beginning, we were not only a small program (ITLP at 25 students/year, then 50/year with SCI-FY), but also a poorly-funded program, forcing us to choose priorities quickly. Most of the energy was simply poured into the fundraising-and-program-delivery cycle. We decided early on that to make a difference, we needed to seek a population that was not being reached and envelop them in a long-term comprehensive service, with preparatory academic, social and leadership guidance. In our ten years, we have served 153 students, each averaging 2 ¼ years in our program. What emerged was a program with four overarching goals, set up in a tiered structure. These are listed below; however, in the first decade of BFOIT, evaluation of achievement and tracking of the participants has evolved slowly. There has been no dedicated funding for a staff evaluator, so if one of our students left our program and didn't keep in touch with us, we haven't had the resources to seek them out years later to find out where they ended up. We were fortunate that so many students let us know where they matriculated!

We want our students to...

Go to college. We address this with the students by exposing them to local campuses, inspirational messages and other "holistic" strategies listed in Section 5.2 and figure 1. We also educate the families on strategies necessary to prepare for success: involving them in the responsibility of assisting their children in getting to college (even if they did not attend college themselves), as well as other techniques outlined in Section 7.3. Truth be told, almost all students who apply to our program have college on their radar, but most have not a clue on the process, requirements and intricacies of either admission or financial aid. We have found that desire, without knowledge or support, is not effective. Consistently, when our students start with us, they are exposed to relevant information and feel like they are starting from stage one.

Major in computer science at college, or gain computational thinking skills. The field of computing has a tarnished image of late, and market research says that three messages are effective with students: "computing puts you in the driver's seat," "computing opens doors," and "computing empowers you to do good" [WGBH and ACM 2009]. We try to share these messages with the students, provide them with a fun (not frustrating) programming environment with warm and supportive instructors, bring in enthusiastic and inspiring speakers who exude the love of their field, and do everything we can to show computing in a positive light. We also understand that BFOIT is about helping students find their niche. If students discover their real passion, and it is not CS, they are still learning computational and logic thinking skills that will serve them well in their eventual field. Nevertheless, we are delighted that 17 of our alumni have majored in CS and nearly all of our students consider CS and/or engineering seriously.

Attend UC Berkeley. One would think we should not have to work very hard toward this goal; after all, our students all attend local high schools, root for Cal sports teams, and usually hold Cal in very high regard. There are two cases: Some students do not think they will get in, so it is not worth applying. This one is easy: we make it clear that the UCB admissions committee considers many factors in their decision, and they will never get in if they do not apply. The other case is when a student is truly among the best in the country, and gains admission to every top school they apply. This one is tough, since other schools might have a more diverse undergraduate body, or better financial package, or allow the student to "get away" from home. We do our best to expose students to local resources on campus, including introducing them to our engineering professors, financial aid officers, graduate students participating in local efforts to attract and retain students of color and women, etc. Consequently, seven students have matriculated here in the last seven years.

Major in computing science at UC Berkeley. This is truly our holy grail, to enroll one of our own graduates in our highly competitive computer science program. Here there are two scenarios: (a) a student intends to major in computing in college but doesn't think they can get in or succeed at Cal, and (b) a student is admitted to Cal but wasn't considering computing as their major. Both of the previous two points describe our strategies to attract these elite students, and we are quite proud of the four who have joined our UC Berkeley CS family in the last five years.

3.5 Oversight & Personnel

Here we describe our organizational structure and the duties of each person or group. We have tried to have the diversity of our administration and faculty mirror that of our students.

Executive Committee: This is a small group, mostly comprised of our founders, who oversee the Advisory Board, and suggest and support any major organizational changes.

Advisory Board: These include our faculty advisors, the long-term program and technical leads, and other UC Berkeley staff who have worked in outreach. Their task is to suggest funding opportunities, help find replacement leads should that need arise, and generally steer the ship.

Faculty Advisors: These are 2-3 computer science faculty who sit on the advisory board, act as liaisons for the department (e.g., help reserve classrooms and labs), often give the summer institute keynote address and perhaps a research talk, help find technical leads, and most importantly, oversee the computing curriculum.

Executive Director: This person reports to the advisory board as well as the Executive Director of ICSI, and is the "face" of BFOIT. This person's task is to secure funding, provide vision and oversee operations. In our particular case, our director serves as the ITLP and ET program coordinator. Currently, we have one person serving part-time in this role.

Program Coordinators: There is one program coordinator for each of the groups, responsible for the recruiting, admissions, preparation, and leadership of our summer institutes, as well as sustaining the support and yearlong connection with our students and families. Program Coordinators are hired as part-time ICSI staff. More details are available in Section 4.1.

Technical leads: We have one technical lead for each of the groups, responsible for delivering our programming curriculum to students in the computer lab. The lead is not necessarily involved outside of the summer institute, or even with non-programming activities during the summer institute, but can be. We have been fortunate to have the same person, a retired computing engineer with a love for teaching, serve as ITLP's technical lead since its founding. He almost single-handedly built the ITLP curriculum, described in Section 5.1. When he was not available these past two summers, he mentored a local AP computer science teacher (who had already been using the material in his class!) to teach the class. With SCI-FY, we've had a variety of outstanding teachers fill this role – some graduate students and some local middle-school teachers. We provide an honorarium for technical leads as well.

Volunteers: They help run the summer institute, serving as tutors during the computer lessons and assistants during other activities. These have been BFOIT alumni and UC Berkeley undergraduates who believe in our mission. Volunteers typically choose one of the two groups (ITLP or SCI-FY), and remain with them throughout the summer institute. Volunteers are typically not involved during the rest of the year.

4. SCI-FY

Science for Youth (SCI-FY) is the middle program of the three-stage BFOIT pipeline. It serves an urban population of twenty-five ethnically and socio-economically diverse middle-school (6^{th}-8^{th} grade) students during the summer and academic year. Students take computer classes, attend field trips, explore science in web-based and classroom environments, and are introduced to different fields of engineering and computer technology through project-based learning. In the following sections, we describe the role of the program coordinator, as well as the different facets of learning to which our students are exposed: with technology, with peers, with the teacher, and with the computer.

4.1 The Role of the Program Coordinator

The Program Coordinator of SCI-FY serves as a source of encouragement to the participants by challenging them to stretch their thinking andparticipate in new learning activities (e.g., robotics, building bridges, etc.), and also celebrates milestones in their learning. This is accomplished by helping students make real-life connections with science, engineering, mathematics, and technology. Students participate in workshops, lectures, seminars and informal discussions where they learn about vital issues, acquire skills and develop strategies that can be applied to meet interests and needs in their respective communities. Students also attend scheduled field trips to local science, engineering and technology museums.

The responsibilities of the SCI-FY Program Coordinator include planning and developing the curriculum for the academic-year and for the two-week Summer Institute. There, students meet with professional experts, educational leaders, college professors and researchers in the fields of information technology, computer science, science, mathematics, and engineering. The coordinator also mentors any volunteer assistants (usually a handful), providing a supportive environment for these young teachers to share their enthusiasm and energy with our students.

One of the primary goals of the SCI-FY's Program Coordinator is to incite students' interest in STEM by designing lessons that deepen their content knowledge, strengthen their scientific and meta-cognitive thinking, and help them to see real-life connections. For instance, students complete traditional science lab sheets in which they have to describe the lab, formulate a hypothesis, test their ideas and summarize their results. Students receive guidance in discovering new STEM concepts, completing learning tasks, and making connections with their prior knowledge. These learning objectives are achieved when they are challenged to answer high-level questions about their tasks, their learning and the strategies they use to complete their assignments.

Learning is a developmental process of constructing one's own knowledge [Kroll et al. 2004; Vygotsky 1978]. When functioning as a teacher in SCI-FY, the Program Coordinator uses supportive technologies (including web-based techniques) to help scaffold the students' learning and involve them in the process of constructing their own understanding. When students engage in the meta-cognitive process, they are involved in planning, monitoring, evaluating, selecting strategies, and having an awareness and knowledge of the resources they need [Gordon 1996]. One way to improve meta-cognition is to create an environment that promotes it [Schraw 1998]. When building knowledge through the use of web-based learning environments, SCI-FY students' meta-cognition is developed or enhanced in the following ways: learning with technology, learning collaboratively with peers and learning with the purposeful instructional intervention of the Program Coordinator.

4.2 Learning with Technology

SCI-FY students interact with each other and with the web-based learning environment in various ways while learning. Webster's Dictionary defines learning as the act of acquiring knowledge or skill through reading, performing various tasks and/or through study. Learning is further explained as discovering or verifying information through inquiry and analysis. Research posits that web-based pedagogical tools (WBPT) provide a platform that can help aid in the development of meta-cognitive skills such as self-awareness, self-reflection, self-observation, and problem solving [Dabbagh and Kitsantas 2005; Hadwin and Winne 2001; Mcloughlin and Hollingworth 2001].

We use a system designed and implemented here at UC Berkeley, called Web-based Instruction in Science and Education (WISE). It is an on-learning environment that promotes the construction of knowledge through the completion of inquiry-based projects [Tate 2005]. For instance, when interacting with it, students answer questions (or respond to prompts) in text boxes, and they also discuss passages of text, directions, and their math calculations. They make predictions and test their ideas while manipulating simulations of motion-oriented objects and characters. They also interpret visual aids, solve multi-step problems, and record their findings on supplemental worksheets. As they work in pairs, they collaborate with each other by sharing their learning tasks. Through joint-task completion and collaborative problem solving, they co-construct one another's understanding of science concepts and problem solving techniques [Harrison 2009], and develop knowledge in STEM areas by using the following learning habits:

- Re-reading technical text to refine their understanding of difficult or vague text.
- Note-taking skills to distinguish between important and unimportant information.
- Reflection to establish connections between questions, text, and problem solving.
- Self-talk or "talking out loud" as a way of learning and processing ideas. This self-reflection develops an awareness of their learning tasks and science concepts, and allows them to critique and monitor each other's ideas and problem solving steps.
- Verification, or "sanity checking" skills to check the accuracy of a solution.

Students access visual aids in various ways while making meaning as they complete learning activities in WISE. Some of the learning skills they employ are:

- Interpreting maps, reading and counting markers on line graphs, using a compass and connecting visual aids to the learning tasks.
- Analyzing linear functions in terms of identifying increasing and decreasing graphs, positive/negative slopes and positive and inverse relationships.
- Modelling or representing their understanding of scenarios using moveable objects and testing and interpreting simulations of real-life experiences.

Guided instruction offered by the Program Coordinator affects SCI-FY students in the following ways:

- Students reflect on questions; this prompts their thinking and meaning making.
- They become more resourceful while learning in a Web-based environment (e.g., accessing hints, identifying suggestions for problem solving).
- Students learn how to identify steps of the scientific method embedded in the web-based lessons so they can differentiate between questions that require them to formulate a hypothesis and those that prompt them to solve multi-step problems.

When using WISE, in addition to responding to questions in text boxes, they record data from their problem solving on worksheets. They use this written data with recorded notes to help monitor their work completion and identify useful information for solving problems. While completing lessons, they respond to questions posed by the Program Coordinator that require them to articulate their understanding of science concepts and scientific processes of thinking (prediction, conclusions, testing ideas, modifying strategies). This reflective way of learning allows them to make their ideas and understandings explicit (or make their thinking visible) for evaluative purposes. When students answer questions, they reflect on previously completed lessons and they also seek to make connections between their learning tasks, the science concepts, and problem solving strategies.

4.3 Learning with Peers

Students work collaboratively with learning partners in WISE, and this enables them to have discussions around learning tasks, science concepts, and their problem solving strategies. Students engage in discourse with each other (after being encouraged by the teacher) and this affords them opportunity to monitor the accuracy of one another's ideas. They discuss their problem solving strategies out loud with each other. Students also monitor one another's work completion by referring to features in the Web-based environment designed to guide them in completing multiple lessons within each activity. They listen to each other's comments, evaluate one another's statements for accuracy, and support each other in co-constructing more accurate knowledge about their learning tasks and the science concepts under study.

4.4 Learning with the Teacher

Teaching with technology requires an awareness of the role technology will play in acting as a learning aid and a resource for students as they interact with a graphical user interface. As the teacher on record, the Program Coordinator assumes the responsibility for facilitating the learning of SCI-FY students as they interact with web-based learning environments and each other. The instructional intervention of the Program Coordinator helps students reflect more on their ideas and evaluate the accuracy of one another's problem solving. This is achieved by asking them questions during their learning that causes them to become more aware of their learning tasks, their understandings, and their misunderstandings.

Web-based learning environments can help students develop knowledge about STEM areas. WISE has features and functions that prompt students to think critically about science concepts and their relationship to problem solving strategies. However, the role of the teacher is a very crucial component of learning with technology. While teaching with technology, the teacher maintains the instructional responsibilities of selecting learning activities, conducting formal and informal assessments of learning, identifying teachable moments, and facilitating enriching learning experiences.

Shared learning begins when students reach an agreement to divide learning tasks among each other. This kind of learning is cooperative and collaborative. When students share learning tasks with each other, they ensure mutual involvement in completing activities. In a web-based learning environment, there are several responsibilities that students must accept such as typing text on the computer, reading chunks of text, and interfacing with the environment to move from one activity to the next. Some web-based environments also require students to reflect on previously completed activities, use worksheets as resources, and surf the Internet to gather data. When SCI-FY students are using WISE, they are expected to work in teams with their learning partners. This implies that they are also expected to share their learning responsibilities. However, this does not always occur naturally. At this point, it is the Program Coordinator's responsibility to facilitate a collaboration to ensure that students have a stake in their learning and to help encourage a team-oriented approach towards solving experiential problems in a web-based environment. This type of experiential education can lead to an increase in knowledge and skill [Dewey 1938].

4.5 Learning to Program

We have iterated through a number of programming environments to identify the one most appropriate to prepare SCI-FY students for ITLP and beyond. As a baseline, we develop our students' capabilities far beyond the typical goals of keyboarding and basic application use. We want to provide real opportunities to engage in the authentic practice of programming, supported by computer science students and professionals.

In the early years (2004 & 2005), our students programmed Lego Mindstorms™ robots using laptops, and really enjoyed the hands-on nature of the projects. However, we had some concerns that the experience would not fully engage everyone, especially the female students. So, in the summer of 2006, with the buzz of websites MySpace and Friendster, we taught our students HTML and how to make their own web pages. Although the students were motivated by their tasks, we felt we could offer the students greater challenges. The following year, motivated by the growing body of research looking at using Alice to develop interest in computer science of underrepresented students [Kelleher and Pausch 2007], we adopted Alice as our programming environment. While our students found Alice easy to learn, they were often frustrated manipulating the characters in the 3D environment. In 2008, because of the (un)availability of technical leads, we returned to Web projects with Flash.

We transitioned to the Scratch programming language in the summer of 2009 [Resnick et al. 2009]. Scratch, building on the pedagogical innovations of Logo [Papert 1980], provides an environment that we have found best supports first-time students developing computer programs. Scratch also offered an environment where students can make wonderful interactive games and movies, and easily share with friends on the Scratch website. Like Alice, the programming environment scaffolds successful program creation, without syntax errors, by offering visual cues and constraints to guide the construction of programs. Unlike many other programming environments, in Scratch the creation of an executable program is trivial. This allows students to be very productive, focusing on what they want to do, rather than getting bogged down in syntax. The summer 2009 students authored relatively complex programs, mostly games.

5. ITLP

The ITLP program is the final stage of the BFOIT pipeline. It consists of a two-week summer institute, as well as year-round involvement, for 25 high school (9^{th}-12^{th} grade) students. We have rolling admissions, but with very few students dropping out of our program, and any free spots opened up by graduating seniors quickly filled by SCI-FY graduates, we are always at maximum capacity. The technical and holistic programs of our institute are described in the following two sections, with the year-round activities listed in Section 7.6.

5.1 Technical Summer Institute Program

ITLP's curriculum has been significantly refined over its ten years of existence. Its roots are in MIT's Logo culture, and extended by Brian Harvey here at UCB [Harvey 1997]. Ideas driving its evolution have come from Polya's classic problem solving text [Polya 1973], as well as the "Being Fluent with Information Technology" report [CSTB 1999] and ACM's K-12 model curriculum [ACM 2003]. Our promise to our students is to help them learn how to think, use logic and how to approach solving a problem. They learn that writing computer programs can be an effective and powerful problem-solving tool.

For the first few years, the introduction to programming piece was simply an informal workshop where we picked a project (e.g., the game Mastermind) and worked with all of the students as a group, writing the program. It was entirely hands-on time in a computer lab, and the instruction took the form of show and tell through an innovative 'theory and practitioner' model with Professor Harvey and Guy Haas. We used the programming language Logo the first two years. We attempted to switch to Java with a TurtleGraphics package the third year, but returned to Logo the following year, extended a bit with a few concepts from Java (e.g., events).

Starting in the fourth year, and continuing ever since, we used our interactive web site to present the material [Haas 2010]. Our Logo programming environment written in Java has allowed us to embed interactive exploration (writing small, simple Logo programs) within the lesson text -- new learned concepts can be explored on-line as students read through the lessons. This programming environment also runs as a standalone application so that larger programs can be written over multiple days. In this mode of use, the look and feel was cloned from an Emacs + Scheme environment.

In the past six years, the lessons have been modified and rewritten based on feedback from students and other instructors, from as far away as the United Kingdom. We have also tutored individuals with e-mail support, younger (than ITLP-age) students, and even a few older individuals exploring programming. Of course, we would love for our lessons to be fully stand-alone, for distance learning. We are making slow and steady progress towards this goal.

Most of our students come to us with no experience with programming, but an intense desire and excitement to learn. In terms of what problems the students work on, we have them start off with art and geometry-based lessons. The real challenge for them is to develop a process, and how to march toward the goal through an ordered list of steps. Experience has taught us that all of our students like animation; some like games, others story-telling. We found that very few of the students liked to read through the detailed lessons, which drove us to shorten them and provide more interactivity. However, those who did complete the lessons on their own did very well, were among the best students of the year and usually went on to pursue computer science at college.

Fig. 2. Two proud SCI-FY students demonstrate their electronic circuit during the 2009 closing ceremonies.

The students love to show off what they have accomplished during the summer institute. While all the students demo their projects to their class in the computer lab, we let them choose the best programs to demo during our awards ceremony, attended by all BFOIT students and parents (figure 2). The pride that flows through the room (parent to child, teacher to student, and peer to peer) is tangible. It serves as inspiration for our SCI-FY students to see what they can achieve and is a great way to end our program.

5.2 Holistic Summer Institute Program

When not programming, our ITLP students are engaged in a number of activities to broaden their horizons and prepare them for college. These have included:

- Ice breaker activities
- Hearing a panel of under-represented UC Berkeley students (undergrads and grads) talk about their experiences, and share advice for the next generation
- A "women's lunch" with accomplished academic and industry women (of all races)
- Field trips to Stanford, LucasArts Film Studios, the San Jose Tech Museum, an East Bay sanitation facility, the Exploratorium (a world-class science museum), Lawrence Berkeley Laboratory, Lawrence Hall of Science, UCB on-campus experiment / robotics labs, Microsoft and Pixar Animation Studios
- Time management and money management seminars (a new game was invented to help students understand the impending reality of managing money on their own)
- Guest speakers from the UCB admissions and financial aid offices, Academy of Arts University and the broader tech community, PIXAR and other industry players.
- Research talks and demonstrations of projects by UC Berkeley faculty and ICSI staff on topics such as Internet security and computational game theory
- Inspirational, "We believe in you, you CAN make a difference, you CAN get accepted and succeed in college!" speeches from EECS faculty
- Self-actualization exercises to help them know themselves and their strengths and weaknesses both socially and cognitively so they are not drawn into self-defeating activities
- Watching Oprah Winfrey's Leadership Academy for Girls video, helping them understand real deprivation and how technology can bring transformative change (and BFOIT students' privilege) to real peoples' lives, particularly as it pertains to empowering women.

6. RESULTS

In this section, we share our student demographics and testimonials. We also describe some early results from research conducted the last two years that investigate the relationship among computer programming in BFOIT, spatial thinking and gender, and conclude with comparisons to similar programs.

6.1 Student Demographics

Our students' demographics for the 2009 ITLP program in terms of racial/ethnic breakdown: African American: 42%, Asian American: 29%, Latino: 25%, and Multiracial: 4%. In SCI-FY, our male/female ratio was 56/44, but in ITLP it was 25/75! For ITLP this is historically consistent, and the result of a conscious decision (since the second year of our program) to heavily recruit high-achieving girls. As a comparison to years past, in 2005 the ITLP gender ratio was male/female: 44/56; in 2006 it was 41/59;

in 2007 there was an unusual blip at 60/40; in 2008 it was 36/64; in 2009 it was 25/75. We place a high value on recommendations and actively ask for referrals.

In SCI-FY, students who had just finished 6th, 7th, and 8th grade numbered 12, 6 and 7. In ITLP, students who had just finished 8th, 9th, 10th, 11th and 12th grade numbered 1, 7, 5, 3, and 9. A large number of students repeat from summer to summer; 68% for SCI-FY and 76% for ITLP.

6.2 Testimonials

It is hard to measure the direct impact BFOIT had in turning non-college-bound students around, or how BFOIT affected decisions to major in computing. One of our major goals moving ahead is to develop a comprehensive evaluation plan, and we have enlisted university faculty to help with this. However, when we ask our alumni and their parents what they thought of the program, the response is always overwhelmingly positive. Here are some student testimonials:

"My experience in SCI-FY was fun; I really liked learning about engineering jobs."

"While SCI-FY's program is called SCIence For Youth, this really doesn't explain what the two week camp is all about. This camp goes far beyond basic science. I would recommend this camp to a friend without hesitation. It is too good of an opportunity not to. It should almost be illegal that a camp like SCI-FY is free. SCI-FY has given me things that I can and will apply to my life forever."

"It has meant a lot to me. I have learned a lot of new information that will really help me with my future. I have learned a lot from people who have gone down the roads that I will soon go down."

"Being able to participate in BFOIT has really meant a lot to me. Even though the program was 2 weeks long it will last with me for my whole lifetime. Even though I'm a minority there are still people out there to help boost me up. I got to learn java program, HTML, and plentiful information through speakers and presentations. This program has changed my life. Now instead of sitting in front of a television, I'm now sitting in front of a computer, programming, doing hypertext language and improving my path to my future dream, to college and success in life."

"Participating in BFOIT to me has meant a lot. By coming here this summer, I learned that I am more intelligent than I think I am. And that feels good. =)"

"The thing that surprised me about BFOIT was that it was real. Whenever I join programs like this, they are very easy or boring but when I came for a week to BFOIT I told myself everything is new to me. I started to learn things that I never thought I would learn."

"The guest speakers were the most beneficial part of the program for me. From them I learned so much so early. It was really motivating to here from the women in technology. It made me feel like I would have a place in technology too."

6.3 Spatial Reasoning

Wai, Lubinski, and Benbow [2009] recently reported on a fifty-year longitudinal study demonstrating the unique contribution of spatial ability towards individuals' success in STEM. Spatial ability is not simply a unitary cognitive process used only in a specific domain. Rather, it is used in fields such as engineering, architecture, piloting, surgery, chemistry, and more recently demonstrated, computer science. Therefore, it makes sense to develop curricula to *train* spatial visualization, as reiterated by a recent NRC report [Downs 2006]. Research suggests that such an intervention could improve students' spatial reasoning skills [Ceci et al. 2009], which might increase their likelihood and success in pursuing fields of science and engineering that require high levels of spatial reasoning. We propose that an intervention using a geometrically oriented programming language, like Logo, may be able to enhance students' spatial reasoning skills to this end.

While research suggests that spatial ability is essential to success in other STEM fields [Holden 2009], it has only recently been suggested that this applies to programming. Current research points to the relationship between different programming skills (such as debugging and code navigation, e.g., Jones & Burnett [2008]) and spatial ability (such as mental rotation, which is the ability to imagine things move in one's head [Shepard and Metzler 1971]). Jones and Burnett studied individuals in management of information systems courses and CS courses. They found that in CS courses, students with higher spatial ability (as measured by a mental rotation task), performed better in the course. There was no correlation with spatial ability and performance in the management of information systems course.

These recent findings motivate our question of whether we can improve students' computer programming performance by improving their spatial ability. Also, it is possible that the task of programming itself improves spatial abilities. A possible impediment to helping students be successful in CS or other STEM fields is that one such underrepresented group, females, appears to be outperformed by males on psychometric tests that involve performing mental spatial transformations [Halpern, 2000]. While specific spatial training has been shown to be successful [Ceci et al. 2009], we believe that it may be possible to develop these spatial reasoning skills through the practice of programming.

Specifically, we work with students in an implementation of the Logo programming environment that forefronts spatial reasoning skills as an opportunity for training and enrichment. For example, students write spatial commands that make the turtle move on the screen. It could be that Logo does improve spatial visualization ability; to find out, we have engaged in a longitudinal study of Logo programming and spatial visualization ability.

For the past two years, we have been tracking BFOIT students' mental rotation ability and perspective-taking ability. Participants completed standardized tests of spatial ability, which was an adapted version of Guay's [1976] *Visualization of Views* Test [Eliot and Macfarlane-Smith 1983] and the Vandenberg and Kuse [1978] *Mental Rotation* Test. Preliminary analysis of performance on the mental rotation test shows that there is a modest correlation between the number of years that students have been in BFOIT and their mental rotation score. These results suggest that individuals who attend the BFOIT Logo programming course for more years also have higher mental rotation ability [Jones and Burnett 2008]. Linn and Peterson [1985] showed that males score higher on the mental rotation test compared to females, so we performed an analysis to investigate sex differences in our sample. Performance for males and females was not significantly different [Khooshabeh, in preparation]. This suggests that Logo and our curriculum seems to be bridging the gap in mental rotation skill between the sexes.

6.4 Comparisons with Similar Programs

To place the BFOIT outcomes in context, it is useful to compare with similar outreach initiatives. Unfortunately, programs of our size & funding are either rare, not publicized well, or have not collected rigorous outcome data (similar to our early years). The comparative data we did acquire were for larger, federally and/or state-funded programs. They operated with far greater budgets (usually over 10 times that of ours), and staff, including dedicated research evaluators. These programs offer insight into the potential for greater impact, and if BFOIT were more generously funded in future, longitudinal tracking of the students.

Data from the campus Center for Educational Partnerships, UC Berkeley, show program outcomes for the statewide Early Academic Outreach Program (EAOP), a state-funded academic preparation program that operates at multiple campuses throughout the UC System. These programs target low-income, first-generation college students, and are not focused uniquely on STEM. The Student Academic Preparation and Educational Partnerships Report [SAPEP 2010] indicates that the percentage of students going on to college from the 2009 cohort is quite high; about 70% of participants attend some form of postsecondary education. The largest percentages go on to community colleges (29%), and those attending the California State University system follow at 19%. The UC System enrolls about 16.5% of the students. Six percent enroll at private or out-of-state universities.

Another point of comparison is the collection of outreach programs sponsored by NSF Science and Technology Centers (STC). The STC's and Engineering Research Centers (ERC) are generously budgeted for education and pre-college outreach. A Berkeley STC ERC, the Synthetic Biology Engineering Research Center (SynBERC), runs several high school programs, including the 8-week introductory College Level Experience in Microbiology (iCLEM) at UC Berkeley, the Saturday Engineering and Enrichment Discovery Academy (SEED) Synthetic Biology Course at MIT, and the UCSF/Abraham Lincoln High School iGEM program at UCSF. Like the EAOP programs cited above, SynBERC focuses on diverse and low-income students from inner-city public schools. The high school students are comprised of 40% minority (African American, Hispanic, American Indian or Pacific Islander); 56% female; 54% low-income and 55% first generation of college matriculants. Of the 55 high school participants, 39 have graduated from high school, and all have gone on to higher education. Of those, 34 enrolled in four-year colleges, with 6 at UC Berkeley and 5 in community colleges. Of the 39 students who are enrolled in college, 29 are STEM majors.

A third pre-college program that offered data is Environmental Science Information Technology Activities (ESITA), sponsored by the Lawrence Hall of Science (LHS), UC Berkeley's public science center. ESITA is one of many STEM outreach programs that LHS implements. The LHS Director of Research and Evaluation ensures that professional evaluation of these programs is conducted, funded by the same grant that supports the programs. In operation over the past four years, ESITA has as its primary aim to provide opportunities for students in grades 9 and 10 from diverse East Bay and San Francisco Bay Area communities to develop deeper understandings of the nature and conduct of science. The program is designed to increase the students' capacity to enroll and perform successfully in science, technology, engineering and mathematics (STEM) courses in the future. The number of student participants served over the life of the project was 128. Although the project targeted students in grades 9 and 10, many of those who participated remained connected to them for multiple years and ESITA evaluators stayed enough in touch with them to keep track of their educational choices beyond high school. ESITA evaluations show that 95% of participants graduate from high school as compared with 65% of the general school population; 70% enroll in four-year colleges and universities compared with 40% of the general high school population.

Quantifying the success of a program like BFOIT is inherently a hard problem, we believe. A simple elevation of our internal admission criteria toward only top-tier, ivy-league-bound students would obviously yield higher graduation and college enrollment rates; we would simply be riding on the success of these kids and claiming responsibility. Inversely, had we used an intervention model, targeting non-college-bound kids with the hopes of turning their lives around and getting them into college, we would probably have lower enrollment rates than the general population. Since our actual admissions decisions are based on a host of factors (e.g., potential to succeed in our program, parental buy-in, prior computing experience, etc.), we naturally have a mixed (although mostly above-average) group of students with similarly mixed success after high school.

How, then, can one measure the effect BFOIT had on our students? We feel it's the qualitative assessments from Section 6.2 that speak the loudest, and we've included only a handful from the hundreds we've received over the years. These testimonials say that the programs we developed worked for our kids: it gave them confidence they didn't have, showed them computing role models they didn't know existed, opened their eyes to the beauty and joys of computing, and changed their lives in ways they never expected.

7. LESSONS LEARNED

Perhaps the most valuable thing we have to contribute is what we have learned in our ten years of running this program. What experiments worked, and what didn't? What were the keys to success? Where should a coordinator direct time and energy? What was critical to have in place before expansion? After a decade of effort, we humbly share advice for anyone interested in starting or refining a similar outreach initiative.

7.1 Secure Sustained Funding

This past summer, we celebrated our tenth consecutive year running BFOIT. We're somewhat of an institution now, at least as far as local school counselors go, who feed us a steady supply of outstanding young students. This is certainly thanks to our sustained presence; having never missed a year has been one of the keys to our success. Two factors have been crucial: outstanding, dedicated people associated with the program (discussed next) and sustained funding, which has come from a variety of sources. We recommend to anyone considering founding this type of outreach initiative that they have at least five years of funding committed, as well as a financial model for long-term support in place, before they begin.

7.2 Recruit Outstanding People

Since the founding of BFOIT, we've been blessed with a talented and selfless group of staff, advisors and volunteers. Every year our program leads have produced a dynamite summer program, enthusiastic alumni have returned and helped out as assistants, and top graduate students, staff and local teachers have volunteered to be our technical leads.

Fig. 3. Some of the world-class staff that helped run the 2009 Summer Institute.

7.3 Involve the Families

Very early in the process we realized that engaging families would be crucial. To that end, when a student applies to our program, the director or program lead visits the home and meets and interviews the student and the family. In Section 3.4, we mentioned that one of our overarching goals was to turn around a student who might not have been headed for college. Why might a student not have had their eyes on that "prize"? Perhaps their grades had been spotty ... or they had been told they couldn't do it ... or their role models pointed them in a different direction. Perhaps their parents didn't attend college themselves and/or were struggling financially and had steered their child away from that path. This visit is a great opportunity for education of the families:

- How crucial parents (and older siblings) are in a child's academic career
- How simple things like providing a quiet study space can make a real difference
- How valuable a college degree is, particularly one from UC Berkeley
- How valuable an engineering and/or computer science degree is
- How many opportunities are available to computing professionals: salary, quality of life, making a difference, lifelong intellectual stimulation, etc.
- How scholarships can make college surprisingly affordable
- How BFOIT is a great stepping stone to success in college, but requires a commitment from all parties, student and parents

When the visit concludes, the director has a real sense of whether the family will be invested in the academic success of their child. In cases where it appears the student or family won't "buy in" fully, we've denied admission. The visit also allows the family, by meeting our director face-to-face in their familiar environment, to ask any questions they may have, and hopefully take comfort that their little one will be in good hands.

7.4 Build Great Resources

Our ITLP technical curriculum has evolved significantly over the years, and is now completely online with interactive applets and interpreters. It has achieved a striking popularity, with around a thousand pages requested per day, and is the 5th-ranked Google search result for the query “Intro to Programming”, as shown in figure 4. We believe our technical curriculum is the core of the program, and we are proud of the efforts by many people who have contributed to it and helped us revise it over the years.

Our SCI-FY curriculum can be broken into two categories: activities that teach science and engineering, and those that teach computing. Fortunately, the science and engineering program is quite polished, though we regularly fine-tune the projects based on student feedback. In Section 4.5 we detailed how the computing portion has changed almost every year, and in Section 8.3 we mention that it may again. Even with all the annual flux, we feel it has been effective at engaging our students, and conveying the beauty and joy of computing.

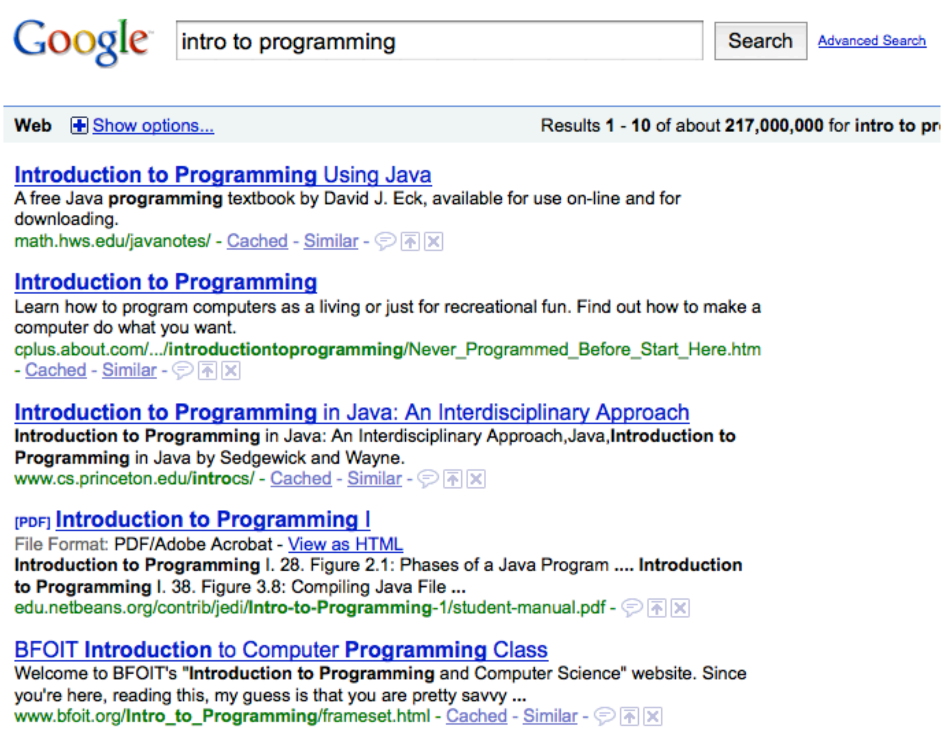

Fig. 4. Our ITLP curriculum was ranked 5th of ~217,000,000 sites on a recent (June 2010) Google search for the phrase: “Intro to Programming”

7.5 Engage Alumni

Our alumni may be our most valued resource. Students still in the program return to their schools and share their experiences with their counselors and classmates; this keeps the applicant pump primed, ala figure 1. Also, year after year, our graduates (now in college) return and donate their time to help as assistants. The value of their contributions cannot be emphasized enough; not only do they help with "crowd control", they assist in the computer lab as tutors, and are perfect role models. For their efforts, they get a pat on the back and the satisfaction that they've given back to a program that gave so much to them. In terms of the reason most programs connect with their alumni (i.e., financial support), we have not gone down that path, but that may be something to explore in the next decade as we look to expand.

7.6 Involve Students Year-Round

We have incorporated a year-round academic and leadership development program, which includes intensive college coaching sessions, confidence building and exposure to opportunities in the computing field through speakers, mentors and field trips. As a sample, here are some of our activities this academic year: SAT prep, college applications & essays, college options, financial aid, and "Techie Saturdays," in which we hold a lecture-style lesson in a traditional classroom. In Section 8.5, we muse about how we might use social networking to further engage our students throughout the year.

8. FUTURE PLANS

We have several areas where we would like to see BFOIT grow in the coming years, with the driving goal to reach and connect with more students, at an even younger age, throughout the entire year.

8.1 Funding Drives Growth

Any plans for growth need to start with an increased level of funding. Our current "single-source" model is stable for the time being, but if that source were cut due to economics or interest, we would most certainly have to scramble. It makes fiscal sense to diversify our revenue stream with corporate sponsorships and/or other foundations, and we are pursuing these leads. There's somewhat of a chicken-and-egg problem here; in order to do this effectively, we'd need to hire a full-time fund-raiser. However, since our current budget is ~$50k, it would require a doubling of our overhead just to pay that person! That said, we're exploring which of the following growth paths can be implemented successfully at our current (or modestly increased) funding levels. BFOIT aligns very well with the NSF Broadening Participation in Computing Program, for example, which could provide multi-year funding opportunities.

8.2 Expand Our Current Groups

The obvious (and perhaps easiest) way to expand BFOIT would be to allow more students into the two existing programs. These are at a very comfortable size now -- with 25 students in each of SCI-FY and ITLP for our summer program, the numbers are manageable. Each fits into one standard-size UC Berkeley classroom and computer lab, each only requires one instructor, and we have found twenty-five to be the sweet spot in terms of building a tight-knit community. We even benefit in terms of space; the two programs fit like a yin-yang symbol into our classroom and computer lab. If we were to grow either program (or both), this perfect balance would indeed change, and we would require additional resources (i.e., staff, facilities and funds). Technical leads are relatively easy to find, since they can be (and have been) drawn from a pool of enthusiastic graduate students. However, finding qualified program leads is not trivial; it takes a very qualified individual to run an effective institute and dedicate their energy to the academic-year program.

8.3 Grow our Elementary School Program

Once we had expanded BFOIT from its ITLP high school program to include a middle-school portion (SCI-FY), we knew that an elementary school program (ET) was next on the horizon. This gained traction with the addition of computer science Lecturer SOE Brian Harvey to the faculty advisory team. In his spare time, he volunteers at a local grade school, teaching computing to 4th graders using Scratch. His curriculum served as the core of our elementary technical curriculum in the summer of 2010, which he led. Initially, and given the timing in the academic-year, we did not need to hire a program coordinator, utilizing our executive director to recruit and assist Dr. Harvey. As the elementary program expands, we will eventually need to add a program lead, hopefully an outstanding, local, 3rd-5th grade teacher. We have mentioned and it is worth repeating that we have found it useful to have program leads also come from underrepresented groups, to serve as implicit role models. Since our SCI-FY and ITLP leads are both African American males, we would aim to find someone to complement them, say "…a wise Latina with a richness of experiences…" [Sotomayor 2001].

In expanding to the elementary level, we will adjust our technical program slightly. Currently, we teach Scratch to our SCI-FY kids, and our homegrown Java + Logo curriculum to our ITLP students. As we explore what we would teach to our 3rd-5th graders, it makes sense to add a third language to the mix, otherwise students who remain in our program could see the same programming environment for six years and probably tire of it. Our plans are to shift Scratch (with its simple, 2D sprite interface) down to ET and re-insert Alice (with its 3D storytelling environment), in its place for SCI-FY. As we mentioned earlier, in ET we will use Dr. Harvey's Scratch "lite" curriculum, quite distinct from what is currently taught in SCI-FY. Another distinction with ET will be pedagogical – we will utilize parents in an active learning role *with* their children during the sessions. We do not know of another program teaching introductory computing to grade-schoolers using this novel, "family knowledge acquisition" method.

8.4 Expanding to Other Campuses

We have often had blue-sky discussions about expanding BFOIT outside the Bay Area. As we note in our Lessons section above, we have found it critical to anchor the program to a few championing faculty near a university, for leadership, reputation, staffing, and free facilities. Thus, a logical expansion might be to another University of California school, with the two closest being UC Davis (1 hour northeast) and UC Merced (2.5 hours east). These should be independent entities (with names appropriate to the home institution, e.g., DFOIT and MFOIT) that we'd help get off the ground.

Each remote campus would need local program and technical leads and volunteers, as well as faculty champions. What makes expansion of this type a no-brainer is that our successful technical and non-technical programs are already polished and ready for export. However, given the extra overhead (and massive funding infusion) it would take to launch a remote site, our preference is to grow our own program first (as mentioned in the previous two sections), before we take a step outside the Bay Area. That said, hopefully this article can serve as a "how-to" guide for someone interested in founding a similar, independent initiative.

8.5 Web 2.0 Learning Community

Our current online presence is a static website, with information about our program, and interactive applets embedded into our Introduction to Computer Programming curricular pages [BFOIT 2010]. To support community building, we have an email list and an active student and alumni community on the Facebook website [Facebook 2010]. The students share photos as well as other social exchanges and even ask each other advice on academic issues they are having. In the future, we hope to play a more active role in this exciting Web 2.0 space [Lewis 2006], and build an online learning community [Sheard 2004]. One example might be year-round programming challenges, in which students would compete and/or collaborate on a problem we would post, or forums for announcing and discussing current events in the computing world.

9. SUMMARY

We have described BFOIT, an initiative founded ten years ago with the goal of broadening participation of computing. By most metrics, it has been a successful program, with 153 outstanding young women and underrepresented students involved, and 65 seniors graduated who have matriculated at some of the finest institutions in the country. Our alumni and their parents have unequivocally said our program was valued and effective, and we seek to grow our program in the near future to increase its impact. We hope that others interested in starting or currently running a similar outreach program might benefit from some of the lessons we've learned.

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