SPECIAL FOCUS ON STEM LEARNING

build IT

Scaling and Sustaining an Afterschool Computer Science Program for Girls

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"I want to be a software engineer because I want to be involved with computers." –Build IT participant

"I would like to create software because I would make a lot of money, and people in these jobs are intelligent." –Build IT participant

"I have been so inspired working with this curriculum and with the whole Build IT team that I have applied to a graduate program…in learning, media and technology." –Build IT facilitator

The program that elicited these statements is Build IT, a two-year afterschool and summer curriculum designed help middle school girls develop fluency in information technology (IT), interest in mathematics and computer science, and knowledge of IT careers. Build IT is a problem-based curriculum consisting of six units that capitalize on girls' interest in design and communication. SRI International's Center for Technology and Learning (SRI) and Girls Incorporated of Alameda County (GIAC) designed the materials and professional development to teach technology and computer science skills not only to girls but also to afterschool facilitators—who are primarily young women—while building facili-

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tators' capacity to provide this programming. To date, Build IT has been implemented at 33 sites and has reached more than 2,000 girls and 50 afterschool educators in the U.S. and Canada through the Girls Inc. network of affiliates. Co-developed and co-owned by SRI and GIAC, with funding from the National Science Foundation and the Noyce Foundation, Build IT is now managed by the Girls Inc. national organization, which provides professional development for all its affiliates.

This paper outlines the need for sustainable, scalable afterschool computer science programs targeting girls and describes the development of one such curriculum. Evaluation research on girls' learning of computer science and on the capacity of afterschool staff and organizations to provide computer science programming leads to our description of a research-based approach to sustaining and scaling the program nationally—an approach that other programs might use to expand their reach and impact.

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The Need for Sustainable and Scalable IT Afterschool Programming

Policymakers, educators, and industry professionals advocate for teaching technology fluency and computer science in and out of school, especially for underserved populations including girls, Latinos/as, and African Americans. Unfortunately, "computer science programs are often overlooked and underfunded, leading to insufficient curricula, a lack of teacher training in computer science, and decreased gender and ethnic diversity in computer science programs and careers" (Coalition for Science After School, 2010). Each year, afterschool educators and learning science researchers create numerous afterschool programs, but many of these programs end with the initial funding. Starting with an important national need, such as the one that Build IT addresses—increasing the number of girls interested in pursuing computer science learning and possibly careers—is an important first step toward building a sustainable and scalable program.

Nationally, women make up half of the workforce but hold one-quarter or fewer of the positions in engineering and computer-related fields. Fewer than seven percent of Latina or African-American women have degrees or careers in these fields (National Academy of Sciences et al., 2010). Yet these occupations are predicted to grow at a rate faster than the average rate for all occupations (Lacey & Wright, 2009; National Science Board, 2010). The fundamental obstacles to girls entering the workforce in science, technology, engineering, and mathematics (STEM) today are the value girls place on STEM careers, their interest in STEM topics, and their expectations of success in STEM fields (Barman, 1996; Brickhouse, Lowery, & Schultz, 2000; Chambers, 1983; Eccles, 1994, 2007; Eccles, Wong, & Peck, 2006). To be convinced of the value of STEM careers and their potential success, girls need to see their interests reflected in STEM courses and informal learning opportunities so that science and math become a central part of the "girls they are" (Brickhouse et al., 2000). Girls should participate in tasks that are relevant to their lives and have social impact; they should also connect with role models in STEM professions and receive feedback and encouragement (Eccles, 1994; Halpern et al., 2007; National Center for Women and Information Technology, 2007). Afterschool settings show promise as places for youth from all backgrounds to gain confidence and interest in STEM careers (National Research Council, 2009).

Reaching Girls and Young Women: Build IT Participants

Programs like Build IT are needed to overcome these obstacles and change the statistics on numbers of women and minorities in STEM careers. More than 65 percent of the girls participating in Build IT are African American or Latina and from low socioeconomic status homes. For many participants, Build IT is one of the few venues that gives them regular access to technology, opportunities to design technological solutions, and exposure to IT careers. The program also uses educative curriculum materials and a train-the-trainer approach to target staff learning, since afterschool staff often see computer science content as daunting. All of the 31 staff members currently facilitating Build IT are women, and 55 percent are women of color. The majority are in their 20s and 30s and were not familiar with computer science concepts when they began the program.

Developing for Scaling and Sustainability

Education research has articulated the features for scaling and sustaining innovations in schools (Coburn, 2003; Schneider & McDonald, 2007; St. John, 2003), including school science programs (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Fishman & Krajcik, 2003). In developing this program, we adapted this research base for afterschool learning. Just as the absence of a clear plan for implementation and scaling hampers efforts to scale STEM innovations in schools (Confrey, Lemke, Marshall, & Sabelli, 2002; McLaughlin & Mitra, 2001), so too does the absence of such plans hinder afterschool programs.

To anticipate the challenges of building a scalable, sustained program, developers designed Build IT to unfold in multiple stages. Rather than waiting to think about sustainability and dissemination until after the program design had been articulated, scale and sustainability plans were integral to the concept.

The co-design process played a key role in these plans. In co-design, researchers and developers lead a highly facilitated, team-based process with practitioners to design and implement prototypes of the innovation. To this process, SRI team members brought their expertise in research and development in the learning sciences, and the GIAC team brought its expertise in implementing youth development programs for girls. This Build IT team worked for three years to develop, implement, and refine the program. In later years, other Girls Inc. affiliates implemented the program, with the national organization leading the professional development.

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Evaluation Findings

Throughout the life of Build IT, internal and external evaluators have used a mixed-methods approach to document changes both in girls' attitudes toward and understanding of IT and in staff members' capacity to sustain and scale computer science programming, examining changes at both individual and organizational levels. Researchers surveyed girls about their perceptions of and interest in IT fields and about their computer usage and skills. The evaluators also assessed participants' understanding of IT concepts. In the first three years of the program, a comparison group from the same schools and communities as program participants responded to the surveys and assessments. In most of its settings, Build IT is part of a larger afterschool and summer program rather than an independent program for which participants sign up. Attendees are thus no more likely than other similar girls to have positive attitudes toward technology or to be interested in IT careers. Researchers also interviewed and observed girls in the program, capturing qualitative data on girls' interest and engagement in IT.

The evaluation team interviewed, observed, and collected implementation reports from staff. Staff also completed online surveys to document their impressions of how well the program met the needs of the girls and of the organization, how well the program addressed professional development needs, their plans to continue or discontinue the program, and their own IT learning and career interests.

Research questions for the evaluation included:

- Are girls engaged, achieving IT fluency, and interested in pursuing IT careers, including taking the necessary high school mathematics and computer science courses?
- Is staff capacity at each site increased and supported to offer this IT fluency programming?
- Is this curriculum sustainable in different settings?

Evaluation results, outlined below, show that Build IT is achieving its goals. Girls' attitudes toward IT and understanding of IT concepts improved. Afterschool staff members increased their capacity to offer the program and developed interest in IT education and careers for themselves. These findings provide evidence for the sustainability and scalability of the program.

Growth in Girls

The data show that Build IT motivates girls to explore IT and pursue IT careers. Girls who saw IT careers as solitary and boring began to see them as collaborative, fun, and intellectually stimulating; many participants started to see IT as a possible career. Their attitudes toward math also changed. In the pilot scale-up, we saw statistically significant improvement in girls' confidence in math and belief in its usefulness. We saw modest (but not statistically significant) improvements in girls' confidence with computers, attitudes toward IT careers, and gender-neutral views of careers. Excerpts from interviews with girls illustrate these changes:

> I might be able to do that.
>
> You could do amazing things.
>
> I thought [the jobs] were hard but seemed kind of fun.

Girls in Build IT strengthen their technology fluency. In the pilot scale-up, girls reported an increase in their technology skills, and assessments showed improved IT knowledge. We saw statistically significant improvements in girls' frequency of computer use, self-reported computer skills, perception of the usefulness of mathematics, and confidence in using math. Similarly, in initial implementation at one affiliate, we saw a statistically significant change in participants' conceptual understanding, as compared to that of a similar group of girls not participating in the program. In addition, girls who participated in two years of the program scored higher on assessments of IT conceptual understanding than girls with one year or less of participation. Finally, data from the initial implementation with one affiliate indicate that Build IT participants with multiple years of exposure to the curriculum increasingly planned to take computer-related courses and college-track math courses.

Growth in Organizational Capacity

To achieve scale and sustainability, a program must not only meet its goals for youth participants, but also build organizational capacity. During the first three years of Build IT implementation and subsequent two years of pilot scaling, all staff and organization leaders reported that the program was a good fit with the needs of their organization, community, and girls; they said that they would implement the program again. Affiliate executive directors found that they could secure local funding for Build IT and similar programs. Of the seven affiliates that participated in the pilot scale-up, six are continuing to implement the program. The national organization hopes to scale Build IT to all of its affiliates.

Preliminary data from the recent (2010–2012) scale-up of the Build IT program to 21 affiliates (33 program sites) reinforced the pilot scale-up findings, showing that the program is sustainable and scalable. Ninety-five percent of organization leaders surveyed said that the program met the needs of the community and aligned with their organization's goals. Leaders said that the program had support from their funders and was not expensive to implement; all but one planned to continue offering the program, though a few noted they would need to find funding to continue. Leaders also said the program was rewarding for staff and girls. One said:

> At our site, we serve a large majority of girls from very low-income, single-parent/guardian households who do not have the economic resources to expose their daughters to IT equipment, programs, or mentors. Without a program like [this one], their daughters would have minimal or no exposure to IT fields, careers, and information.

Additionally, the majority of facilitators—73 percent—said they were comfortable implementing the program; the remaining 27 percent report reported that they were comfortable "to some extent."

Growth in Afterschool Staff

The Build IT curriculum is designed to teach staff as well as girls. Data show that staff who implemented the program often became comfortable troubleshooting technical problems and doing computer programming using HTML or object-oriented programming tools. It was not uncommon to see a staff member rooting in the organization's server closet. One said, "My Internet went down the other day and it said ISP and LAN and all that stuff…and I was, like, 'Wow, I know what these things mean.'" Staff members' comfort with curriculum concepts also grew: they began to successfully incorporate and teach important concepts such as the engineering design process of defining the problem, brainstorming, sketching, researching, developing, testing, and using the new technology.

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Researchers also found evidence that staff gained more than the capacity to teach the curriculum. In a survey on staff capacity and IT learning, more than 60 percent of responding facilitators said the program influenced their career and education plans: 58 percent said they were thinking about or pursuing a career involving STEM and 47 percent were thinking about or pursuing further education in STEM. One facilitator, for example, has moved on to a technology job, and another entered an educational technology graduate program. Two others have added a computer science or technology focus to their postsecondary education. Others have created roles in their organizations as coordinators of the Build IT curriculum, in effect building a career ladder for STEM-focused educators and built-in support for the program. Finally, staff members at the site that co-developed the curriculum have taken on leadership roles by becoming trainers for affiliates new to the curriculum.

Encouraging the facilitators—nearly all of whom are women and many of whom are women of color—to pursue IT careers was not an original goal of the program, but it certainly addresses the national need for more women and particularly women of color in IT. It may seem counterproductive to facilitate staff members' leaving the program; however, from the start, the program development team planned for the high staff turnover that is common in afterschool organizations. In order to promote organizational memory of the program, Girls Inc. affiliate leaders as well as facilitators attend Build IT professional development. Additionally, the curriculum materials themselves are designed to educate new staff members as they prepare activities and use them with the girls.

To achieve "deep and consequential change" (Coburn, 2003) in afterschool STEM learning, our experience and research led us to a co-design process, in which developers from the learning sciences and youth development fields collaborated to develop a rich, usable curriculum that meets the needs of youth and their communities.

Research-based Framework for Sustainability and Scalability of Afterschool STEM

Frameworks for scaling and sustaining school-based innovations provided insights to the program development team for planning the stages of Build IT. Coburn (2003) outlined four interrelated dimensions for scaling and sustaining education innovations: depth, spread, shift, and sustainability. Dede and Rockman (2007) added a fifth dimension, evolution. Developers can think about these five dimensions both sequentially and collectively, as they reinforce one another.

- *Depth* refers to the effect of the innovation on youth learning and educators' practice. Coburn (2003) states that "reform must effect deep and consequential change" (p. 4).
- *Spread* is the traditional notion of scale: the spread of a reform to a greater number of sites.
- *Shift* in ownership requires that the practitioners responsible for implementation, not the developers, have full authority, including over ongoing support, professional development, and future implementations.
- *Sustainability* means maintaining the depth of the program—and allowing for acceptable adaptations—over time, under less than ideal conditions.
- *Evolution* of the innovation for sustainability involves three types of innovators: developers, researchers, and practitioners. Practitioners' implementation influences future research and development. Evaluations and assessment tools that informed the original innovation can help practitioners to adapt the innovation and can provide data for funders of the sustained program.

Cutting across all five of these dimensions, researchers developing science curricula at the University of Michigan (Blumenfeld et al., 2000; Fishman & Krajcik, 2003) have identified *usability*—by students, teachers, and administrators—as key to the sustainability of an innovation in schools:

> If an innovation is "usable," this means three things: (1) that the innovation is adaptable to the organization's context, (2) that the organization is able to enact the innovation successfully, and (3) that the organization is able to sustain the innovation. (Fishman & Krajcik, 2003, p. 565)

These researchers note that the innovation is more than the curriculum materials; it includes planning for ongoing support of the organization's capacity to implement effective science curricula. Not only must teachers and students be able to use the materials, but also the organization must have the capacity to use the program. Other researchers of in-school science learning have noted the importance and interplay of the usability of the curriculum and the building of the organization's capacity to offer the curriculum (Cohen & Ball, 1999; St. John, 2003), a capacity that includes alignment with the organization's culture, policy, and management initiatives (Blumenfeld et al., 2000; Fishman & Krajcik, 2003).

Achieving Depth through Co-Design

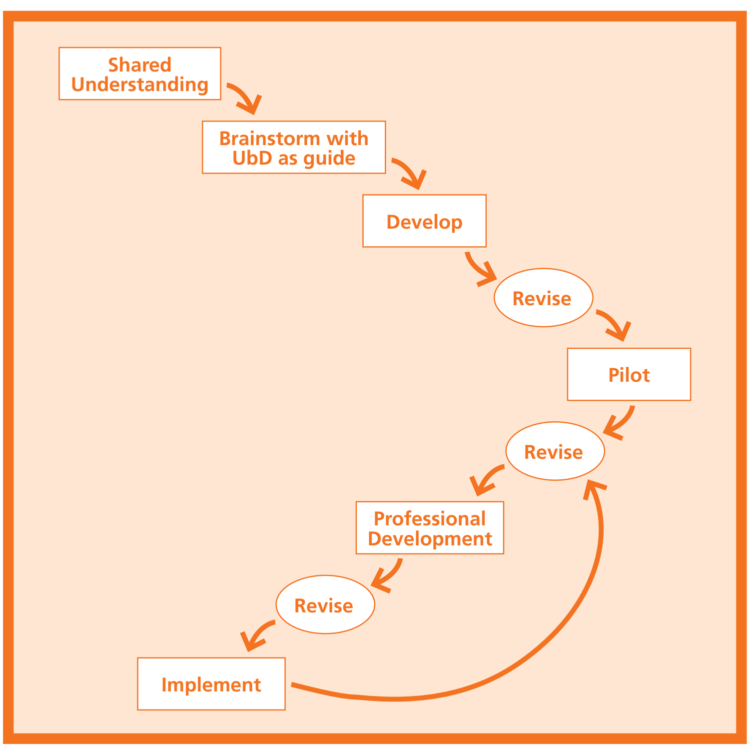
To achieve "deep and consequential change" (Coburn, 2003) in afterschool STEM learning, our experience and research led us to a co-design process, in which developers from the learning sciences and youth development fields collaborated to develop a rich, usable curriculum that meets the needs of youth and their communities. Penuel, Roschelle, and Schectman (2007) define co-design as a "highly facilitated, team-based process in which educators, researchers, and developers work together in defined roles to design an educational innovation, implement the innovation with educators and students as a prototype, and evaluate each prototype's significance for addressing a concrete educational need" (p. 51).

The Build IT team used philosophies and pedagogical approaches from the learning sciences and youth development fields to develop a constructivist, problem-based curriculum. The program's hands-on experiences are not solely computer based; they enable youth to use their bodies, creativity, energy, and visual representations to act out computational approaches to solving problems. The co-design process allowed constant checking of the program's usability for youth and youth development leaders. In addition to iterative co-design, we incorporated the *Understanding by Design* approach (Wiggins & McTighe, 1998) to identify learning goals and ways of achieving them. Learning goals, assessments, and activities were articulated in a language consistent with youth development.

Throughout development, the Build IT team incorporated educative elements in the curriculum that were designed to teach afterschool educators as much as the girls, so that the staff can understand and implement the curriculum. Educative curriculum materials increase educators' knowledge in specific instances of instructional decision making and help them develop more general knowledge that they can apply flexibly in new situations (Ball & Cohen, 1996; Davis & Krajik, 2005). Build IT's educative elements include computer science and IT concepts along with research-based practices for engaging girls in these concepts. These elements reveal the developers' pedagogical judgments and help staff to access information, learn subject matter, anticipate and interpret what learners may think or do, and relate units and big ideas.

Figure 1 outlines the Build IT team's co-design approach. To begin, the Build IT team developed a shared understanding of co-design, the afterschool learning environment at Girls Inc., and the role of each contributor. Next, the team conducted one or two brainstorming meetings using the Understanding by Design approach. The team identified the "enduring understandings" (big ideas) in computer science, discussed products youth could produce or actions they could do to demonstrate their understanding of the concepts, and shared activity ideas that could elicit these products or actions.

Figure 1. Co-Design Approach



Once an outline was agreed on, SRI team members drafted the curriculum, based on their computer science and mathematics expertise, and Girls Inc. team members reviewed it. The groups revised until both teams deemed drafts to be ready for implementation. The team then prepared selected activities to pilot with a few girls and shared the curriculum draft with advisors. The team revised the curriculum again based on this feedback. Another round of revisions came after staff gave feedback on initial professional development sessions. Next, the unit was fully implemented with 15 or more girls. Formative evaluation of the implementation and feedback from girls and staff informed the next phase of revisions. Each unit went through about three rounds of drafting, piloting, and revising.

At first glance, co-design may seem overly difficult: agreeing on curricular goals and following a structured iteration process are time-consuming. Yet co-design can help develop greater ownership over designs, strengthen STEM content, and make designs more usable in real settings (Penuel et al., 2007).

Achieving Spread by Building Partnerships

In order to spread and achieve scale, an innovation must influence the organization's norms and principles, including policies, curriculum implementation, and professional development (Coburn, 2003). Proven impact, ease of use, and fit with the organization are critical factors in achieving scale.

Partnerships can support an innovation's spread. A report on the sustainability of 21st Century Community Learning Centers by The Finance Project (2006) finds partnerships to be essential for long-term sustainability. Specifically, partners should have shared goals, clear roles in program development and refinement, and credibility with funders. Partnerships also have the potential to expand the capacity of programs to coordinate educational and social services for children living in need, so that afterschool programming can be as effective as possible (de Kanter, Adair, Chung, & Stonehill, 2003).

For Build IT, the work began with key partnerships among the two developers, SRI and GIAC, and the Girls Inc. national office, which would provide professional development and scaling support for its network of more than 150 affiliates. Each affiliate has developed further partnerships with local tech organizations, since the curriculum includes connecting girls with women STEM professionals. This strategy of establishing ongoing partnerships with the local STEM community has the potential to keep the program current with STEM changes and to attract new funders.

Developing Ownership from the Beginning Rather Than Shifting

During the initial stages of design and pilot implementation, curriculum developers and researchers typically drive the process. For the Build IT program, the co-design process facilitated a partnership that capitalized on the skills of both organizations. It also anticipated the end of grant funding, so that design decisions were based on how to support ongoing implementation within the larger afterschool program. The youth development organization led implementation from Day One of the project. The Build IT team used the implementation of the curriculum by girls and facilitators as a source of information for making refinements. Professional development began as the responsibility of the learning sciences organization, with an articulated plan for transferring ownership to the youth development organization.

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Sustaining Programs through Professional Development Infrastructure

Professional development plays a key role in sustaining a program. As programs move toward sustainability, resources for professional development and other assistance often dissipate, especially for programs attempting to achieve scale as well as sustainability (Coburn, 2003). In youth organizations, staff turnover is high. Organizations may train staff to implement a program one year, only to lose those staff the next year. A process for inducting new staff to support the program and providing for ongoing professional learning can help maintain capacity.

Build IT addressed this issue by sharing professional development responsibilities with sites from the beginning. A program manager worked side-by-side with learning sciences researchers and program developers to design and deliver professional development. SRI staff led the initial professional development for each unit; for the second implementation, both organizations co-led the professional development. By the third implementation, Girls Inc. staff led the professional development.

Build IT is successful in part because ongoing professional development is part of the infrastructure of Girls Inc. at each affiliate and nationwide. Like many other youth-serving organizations, affiliates experience frequent staff turnover but have a relatively stable core of program managers. The national organization provides professional development on many of its programs; its professional development staff includes Build IT in a suite of STEM programs offered to affiliates. Having a professional development staff and a training infrastructure for face-to-face sessions, webinars, and online support makes Girls Inc. capable of sustaining innovations.

Developing and Aligning Frames That Allow a Program to Evolve

A single project that initiates a cycle of program development typically presents a single "frame" to a potential funder. The term *frame* (Goffman, 1974; Snow & Benford,

1988) refers to a specific definition of a problem, a path to its solution, and a rationale that makes the solution compelling.

A proposal frame—the initial rationale for winning funding—is rarely enough to sustain a program across multiple projects or to convince new groups to fund new development or implementation in new settings. A key task for sustainability is to develop multiple frames for defining problems and to establish congruence among them. This activity of aligning frames cannot be simply "chasing the money," but rather must be a genuine bridging or extension of activity in ways that allow the program to adapt, grow, and even transform as it moves to new contexts.

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The frame for funding Build IT has varied according to the needs and resources of the affiliates and their communities. For example, one affiliate's search for women STEM professionals led to the discovery that the city had an initiative to attract IT businesses. Through collaborations with the city and a local university, this affiliate secured funding for Build IT, identified field trip opportunities, and established relationships with STEM professional role models who regularly participate in the program. This affiliate's frame combined the need for funds with the need for role models. The level of local interest in IT jobs enables this affiliate and others to use Build IT as a marketing tool to fund not only Build IT but other programs as well.

Build IT started with framing a need to encourage girls to pursue computer science and IT careers. At the national level, Build IT's success has made it part of the frame on using evaluation data to show how Girls Inc. programs affect girls. The national organization uses multiple frames of funding, professional development, scale, research, and evaluation to achieve its goals, which include making sure all affiliates can implement Build IT.

Conclusion

Planning for sustainability and scalability from the beginning is an important means of ensuring that programs continue beyond their initial grant funding. The Build IT development team successfully achieved scale by engaging youth development and learning sciences experts in a co-design process, using professional development to continually support the program and transfer ownership to practitioners, and working within an established network of affiliates. As a result, Build IT is having a positive effect on girls and afterschool staff throughout the nation.

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