# I-3 Experience: Expanding Research and Design Opportunities for Underrepresented High School Students

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Dr. Christina Gardner-McCune is an assistant professor in the School of Computing, Human-Centered Computing Division at Clemson University. Her research focuses on gaining a better understand of how students learn and apply STEM and computing content in their everyday lives. She is particularly interested in the iterative design, refinement, and sustainability of curriculum and program development to support computing and STEM learning in formal and informal learning environments. She has designed and piloted a mobile application course for undergraduate non-CS majors through her participation last summer in the national pilot of the new AP CS Principles course. She is currently designing mobile application curriculum with MIT AP Inventor for 8th grade mathematics classes and middle and high school social studies classes. Dr. Gardner-McCune recently completed a year and a half long postdoctoral research position in computer science education at Georgia Institute of Technology's College of Computing where she led the design of the I-3 Experience programs. She holds a B.S. in Computer Engineering from Syracuse University, and earned both her master's and doctorate in Computer Science from Georgia Institute of Technology. She is also a board member of Y-STEM (Youth Science, Technology, Engineering, and Mathematics organization), a non-profit foundation focused on enhancing the quality and accessibility of formal and informal STEM learning opportunities to African American and disadvantaged youth.

**Mr. Darrryl Bryant McCune II, YES Beyond Limits**

Darryl B. McCune II is a certified IT specialist through Georgia's Metropolitan Regional Education Service Agency. For the past two years he has been developing computer science curriculum in collaboration with the office of Outreach, Enrollment, and Community of Georgia Tech. His work has focused on exposing students to computer science through kinesthetic learning and physical computing. He is also certified to teach high school mathematics. In August 2011, McCune's teaching portfolio was selected to be a model by which nontraditional teachers would be trained to develop their own curriculum plans in route to certification at Metro RESA. In April 2012, McCune was awarded an Outstanding Staff Performance Award. Outside of developing curriculum and programming for high school students, during the summer months McCune expands his audience to reach middle and elementary age students with summer camp topics that address topics such as adventures in animation, storytelling, animatronics, programming in java, game design and arduino development.

**Miss Chanteal Maria Edwards**
**Mr. Cedric Stallworth, Georgia Institute of Technology, College of Computing**

Cedric Stallworth's 20 year career as an educator has centered on helping students and their parents make successful transitions from high school to college and from college to the work place. He has developed and run bridge programs that give students and parents practice at the college experience. He has run mentoring programs that contribute to the academic and personal development of students and provide parents with supportive feedback. He is in constant contact with high school and undergraduate students, providing them with encouragement, advice and a sympathetic ear. He considers himself to be a practitioner and has brought that mindset to his role as assistant dean in the College. He has defined the mission of his office to be the creation of a sustainable pipeline of computing talent that begins in elementary school and continues through alumni. In support of that mission he identifies, coordinates and manages resources and personnel that benefit students, their families and the College. He maintains his relevance to the students with a presence in the classroom by teaching introductory computing courses, student enrichment course as well as after school and summer computing workshops. He broadens his impact by sharing his experiences and insights with colleagues as a part of national efforts to increase the numbers of women and minorities in computing. Stallworth earned an M.S. in Computer in 1999 and a B.E.E. in Electrical Engineering in 1990 both from the Georgia Institute of Technology. He has been at the Georgia Institute of Technology since 2008 as an assistant dean of Outreach, Enrollment and Community. Prior to that he was and instructor and a research scientist in the College of Computing.

## I-3 Experience: Expanding Research and Design Opportunities for Under-represented High School Student


### Abstract

This paper will describe a novel approach to engaging under-represented high school students in research and design opportunities at a public university. The I-3 (pronounced "I three") Experience programs aim to engage 9th-12th grade African American, Latino, and female students in research and prototyping activities to increase and sustain their interest in computer science. From Spring 2011 – Spring 2012, 64 students have enrolled in the I-3 Experience programs. Our program has specifically targeted female and underrepresented students (African American and Latino/as): 85.94% of program participants are female and underrepresented students; 61% of our students participated in free and reduced lunch programs. The program has a 71.79% retention rate.

The I-3 Experience is a series of computing afterschool and summer-enrichment programs designed for students who are interested in exploring computing but lack courses at their school or have completed all the available Computer Science (CS) courses at their school and desire to expand their computing skills. The I-3 Experience consists of three program phases: Imagine, Investigate, and Innovate. Each of these program phases engages students in computational thinking and provides opportunities and resources for them to bring their ideas to life through the design of new applications and devices.

Our goal in designing this program was to build on the success of existing K-12 summer camp outreach programs offered at Georgia Tech by offering students an opportunity to pursue their interest in CS through a constructionist and project-based curriculum. As we moved the students from exposure to personalization of the technology they developed, our aim was to increase the number of students desirous of enrolling in college as computer science majors. Our overarching goal was to increase the likelihood of students who apply to computer science undergraduate degree programs. This paper will discuss the program, strategies for program success, and enrollment and participation outcomes of this year long program.


### 1 Introduction

The I-3 (Pronounced "I three") Experience program offered a 21-week after-school program for 9th -12th grade students who are interested in exploring computing. Students went to campus once a week for a 2.5 hours session in the evening. Our goal in designing this program was to build on the success of K-12 summer camp outreach programs offered at Georgia Tech's Institute of Computing Education (GT ICE). Thus, we aimed to offer students an opportunity to pursue their interest in computer science (CS) through a constructionist and project-based curriculum. As we moved the students from exposure to personalization of the technology they developed, we aimed to increase the number of students desirous of enrolling in college as computer science majors.

The I-3 Experience consists of three program phases: Imagine, Investigate, and Innovate. Each of these program phases engages students in computational thinking and provides opportunities and resources for them to bring their ideas to life through the design of new applications and devices. Overall, we used a project-based learning model that ensured that computing content participants learned is largely focused upon what they need to know to develop their projects. By nature, the program was hands-on and allowed participants to iteratively develop and test their project prototypes and learn to program using tutorials we have created or adapted for App Inventor, Scratch, Arduino, circuit design basics, and Game Maker. The I-3 Experience provided students with the opportunities, space, resources, and the encouragement needed to pursue their interests in computing. Our program welcomed all students and is very much aware of the needs of women, African-Americans and Latino-Americans in this field of study. Our goal is to inspire students to see the world computationally, to investigate how technology works, and to use this knowledge to innovate the future of technology.

## 2 Background

Established outreach activities through Georgia Tech's ICE programs offer fourth through eighth grade students opportunities to learn about introductory computing concepts through interactive programming projects [1]. Despite the success of these programs in sparking students' interest in computing through their middle school years, only 25 % of all GA high schools offer computing courses where students can continue their computing education. This has caused a decline or stagnation in students' computing interest and skill development during their 9th -12th grade years. While we've seen increases in the number of schools offering CS courses due to continuous teacher professional development that is happening in the state and a modest increase in students taking the AP exam; we are still struggling with decreased applications rates to undergraduate CS degree programs. In particular, under-represented minorities and women application rates remain low. This ultimately results in a decline of qualified computer scientist in the workforce. Since 2001 there has been a sixty percent drop in incoming freshman who plan to major in computer science. The I-3 Experience programs were designed to address these issues.

## 3 I-3 Experience

The I-3 Experience Programs: Imagine, Investigate, and Innovate; each ran for 5-7 week phases where students cultivated computational thinking, prototyping and project presentation skills all while learning the importance of research and its impact on modern technology.

### *3.1 Imagine Phase*

The I3 Experience began with the Imagine program, which focused on inspiring students to see computing in the world around them. Students were introduced to various aspects of computing and computational thinking through round table discussions of current computing trends and applications, as well as interactive activities that demonstrated how computers work and process information. Program participants had the opportunity to develop project proposals for new applications or devices based on their interest. Students presented these proposals at a parent presentation event at the end of the five week phase.

### *3.2 Investigate Phase*

The second phase of the I-3 Experience was the Investigate program. This phase aimed to equip students with a computational toolkit through engagement in project-based learning. In this phase, participants engaged in a series of condensed tutorial known as Crash Courses. Crash Courses were a set of short interactive instructional activities that introduced students to development environments such as Arduino and App Inventor. The students viewed a few project PowerPoint presentations and a project demonstration that highlighted the efforts of former I-3 Experience participants who completed research and development projects. This allowed them to conceptualize how they could use their newfound tool kits to create dynamic and interesting project prototypes. The investigate phase had two seven week progressions that each ended in a project presentation. The first progression gave the students an introduction in both App Inventor and Arduino. The second progression focused on two key areas of computer design and development: (1) robotics and microcontroller development (Arduino technology) and (2) mobile app designs (App Inventor). The projects students pursued were primarily selected by the students during the Imagine phase of the program. However, students were allowed to pursue new project ideas if they wanted. Participants developed skills in programming, prototyping, project management, public speaking, and presenting in order to successfully design and present their project.

*3.3 Innovate Phase*

In the Innovate Program, the final phase of the I-3 Experience, students were supported and mentored in the creation of innovative devices and applications using the computational toolkit students' developed in the earlier phases of the program. The Innovate phase focused on project development by providing students with a research and development lab environment that provided them with space, resources, and time to bring their ideas to life. Unlike the Imagine and Investigate Programs, students were able to participate in the Innovate Program multiple times to fully develop and implement their project ideas. During this phase students developed high quality prototypes that could be entered into competitions and project showcases at the K-12 and collegiate level. In addition, students with novel projects had the opportunity to apply for a provisional patent.

## 4 Student Presentations, Public Competitions & Research Venues

In addition to the weekly I-3 Experience program meetings, we organized several opportunities for students to exhibit and present their work through showcases, public competitions, and research poster sessions at technical conferences. To prepare students for these presentations we focused on sharpening students' written and oral communication skills. In particular, we focused on helping students to develop formal presentations and posters on PowerPoint or Prezi and orally present their work in conference style presentations and prototype demonstrations. These presentation opportunities were aimed at giving students an opportunity to show off their work as well as assist students in the development of invaluable skills that they could use throughout their college careers.

*4.1 Showcases*

After each 7 week session, students' parents were invited to campus to see their children's work in the program. During the Imagine Phase students presented their work in a conference style format where each group was given 10-15 minutes to present their ideas. During the Investigate Phase students presented their ideas with posters during a poster symposium. During the Innovate Phase students demonstrated their prototypes.

*4.2 AT&T Arduino Challenge Competition*

For the past two years, AT&T hosted an Arduino Challenge competition. The competition was designed to increase students' interest in STEM and entrepreneurship. AT&T provided an introduction to Arduino course where students learned the basics of circuitry, electrical safety and Arduino programming to design simple circuits. AT&T provided us with their curriculum which we incorporated into our modular Crash Courses as part of the Investigate Phase. The I-3 Experience students have participated twice in this competition. The first year we brought two teams and the second year we brought six teams. In order for students to participate in the AT&T competition they had to come up with an innovative prototype as well as develop a business case. During the competition, students presented their business cases and prototypes via teleconferencing to AT&T engineers and executives across the US. Several AT&T national offices participated in the judging and analyzed the design process and challenges the students faced in preparation for the competition.

*4.3 TN-WIC*

The Tennessee Women in Computing (TN-WIC) conference was a regional Grace Hopper conference held in October 2012. We asked four students from our summer pilot program to present their work on two projects. This conference offered students the opportunity to present their work regionally and to get feedback from experts in Computer Science. It also provided them with an opportunity to see women in computing and to receive encouragement. The young women attended keynote sessions where they saw women in industry working in computing, workshops aimed toward undergraduate women, and presented their work in the undergraduate research symposium.

## 5 Participants

Our program targeted 9th – 12th grade students that may or may not have had early exposure to computing, had limited access to computing courses or extra-curricular activities at their schools, or maxed out opportunities in their high school to expand their interest in computing. Participants came from six metro-Atlanta school districts with the majority of students coming from Atlanta Public School district and South Fulton County schools which serviced underrepresented students. We had four cohorts of students enter into our program Spring 2011, Summer 2011, Fall 2011, and Winter 2012. Spring and Summer 2011 were pilot programs (Cohort #1 & #2). Fall 2011 (Cohort #3) and Winter 2012 (Cohort #4) were the first groups of students to participate in the formal I-3 Experience Programs.

Overall we've had 64 students participate in our programs: 43 were male and 21 were female. The participant population has consisted of 46 African Americans, 10 Whites, 2 Latinos, 5 Asian and 1 Native American student. Female and underrepresented students made up 85.94% of our student body; with 61% of our students participated in the free and reduced lunch program, a socio-economic indicator of financial need. Table 1 indicates the number of new and returning participants for each program session. Table 2 indicates the gender breakdown of all participants (new and returning) for each session. Table 3 shows a class-standing breakdown of all participants (new and returning) each session. Table 4 shows the racial ethical composition of all participants (new and returning) each session.

**Table 1 Participant Cohorts**

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 | Cohort #3 | Cohort #4 | Cohort #3 |
|---|---|---|---|---|---|---|---|---|
| | After-school Pilot | Summer Pilot | Imagine | Investigate I | Imagine | Investigate II | Investigate I | Innovate |
| | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 | Winter 2012 | Spring 2012 | Spring 2012 |
| New Students | 17 | 12 | 9 | 16 | 10 | 0 | 0 | 0 |
| Returning | 0 | 3 | 0 | 4 | 0 | 21 | 9 | 19 |
| Total # of Participants | 17 | 15 | 9 | 20 | 10 | 21 | 9 | 19 |

**Table 2 Student Participation each Session (All Participants)**

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 | Cohort #3 | Cohort #4 | Cohort #3 |
|---|---|---|---|---|---|---|---|---|
| | After-school | Summer | Imagine | Investigate I | Imagine | Investigate II | Investigate I | Innovate |
| All Participants | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 | Winter 2012 | Spring 2012 | Spring 2012 |
| Female | 5 (29.41%) | 7 (46.67%) | 5 (55.56%) | 3 (15.00%) | 2 (20.00%) | 6 (28.57%) | 2 (22.22%) | 5 (26.32%) |
| Male | 12 (70.59%) | 8 (53.33%) | 4 (44.44%) | 17 (85.00%) | 8 (80.00%) | 15 (71.43%) | 7 (77.78%) | 14 (73.68%) |

**Table 3 Class Standing Demographics (All Participants)**

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 | Cohort #3 | Cohort #4 | Cohort #3 |
|---|---|---|---|---|---|---|---|---|
| | After-school | Summer | Imagine | Investigate I | Imagine | Investigate II | Investigate I | Innovate |
| High School | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 | Winter 2012 | Spring 2012 | Spring 2012 |
| Senior | 3 (17.65%) | 9 (60.00%) | 4 (44.44%) | 8 (40.00%) | 0 (0%) | 7 (33.33%) | 0 (0%) | 7 (36.84% |
| Junior | 8 (47.06%) | 2 (13.33%) | 0 (0%) | 11 (55.00%) | 2 (22.22%) | 9 (42.86%) | 2 (22.22%) | 7 (36.84%) |
| Sophomore | 1 (5.88%) | 1 (6.67%) | 2 (22.22%) | 1 (5.00%) | 7 (77.78%) | 2 (9.52%) | 7 (77.78%) | 2 (10.53%) |
| Freshman | 5 (29.41%) | 0 (0%) | 3 (33.33%) | 0 (0%) | 1 (10.00%) | 3 (14.29%) | 0 (0%) | 3 (15.79%) |
| Rising College Freshmen | 0 (0%) | 3 (20%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |

**Table 4 Racial/Ethnic Demographics (All Participants)**

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 | Cohort #3 | Cohort #4 | Cohort #3 |
|---|---|---|---|---|---|---|---|---|
| | After-school | Summer | Imagine | Investigate I | Imagine | Investigate II | Investigate I | Innovate |
| all participant | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 | Winter 2012 | Spring 2012 | Spring 2012 |
| African Am. | 10 (58.82%) | 10 (66.67%) | 8 (88.89%) | 18 (90.00%) | 5 (50.00%) | 20 (95.24%) | 5 (55.56%) | 18 (94.74%) |
| Latino | 1 (5.88%) | 2 (13.33%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Asian/ Indian | 0 (0%) | 2 (13%) | 0 (0%) | 1 (5.00%) | 3 (30.00%) | 0 (0%) | 2 (22.22%) | 0 (0%) |
| White | 5 (29.41%) | 1 (6.67%) | 1 (11.11%) | 1 (5.00%) | 2 (20.00%) | 1 (4.76%) | 2 (22.22%) | 1 (5.26%) |
| Native Americans | 1 (5.88%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |

## 6 Examples of Student Project Work

Student work is a major feature of the I-3 Experience. Students spent roughly 75% of their time in the program imagining a technology of the future that they would like to create to meet a societal need or an entertainment purpose, learning the skills to create the technology, and then actually creating a prototype. Student projects often stemmed from students' interests and the scope of the prototypes depended largely on the collective skills of the group. In this initial offering of the I-3 Experience projects fell into several categories: Music, Fashion, Games, Robotics, and Assistive Technologies.

### *6.1 Music*

The *Musical Tee* Project was a one octave keyboard circuit prototype for a musical t-shirt (see Figure 1). The goal of project was to make practicing music fun and portable. Parts included Arduino, buttons, and breadboard and electrical circuits as a prototype for a musical t-shirt.

**Figure 1 Music Keyboard Tee (left) and Fabric Application (right) Prototypes**

### 6.2 *Fashion*

The *Cozy Coat* Project was a heated jacket for anemic individuals used to keep them warm and fashionable while indoors. This design used an Arduino, heating elements, and potentiometer (see Figure 2).

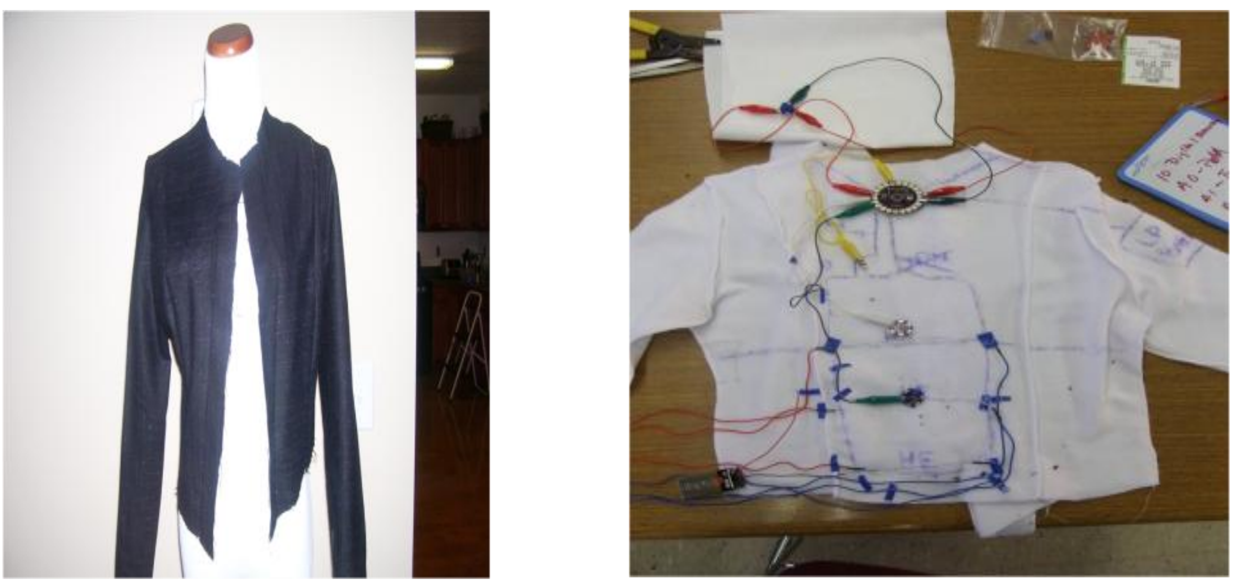

**Figure 3 Cozy Coat Jacket Outer (left) and Circuitry Interior (right)**

*Sneaker Seeker* was a mobile application to help sneaker fanatics and enthusiasts locate and acquire hard to find retro and limited edition sneakers.

6.3 *Games*

The *G-Sim* Project was a 5-level game created with GameMaker with an accompanying Arduino-based game controller prototype with four directional buttons with the goal of translating controller movements into a glove controller (See Figure 3). The purpose of this project was to promote more user brain and physical activity while playing games.

**Figure 3 G-Sim Four Button Directional Controller (left) and Glove Controller (right)**

*Lawnmower man* was a 10 –level 2D Game created with Game Maker and an Arduino based game controller. This was a software only prototype.

*Universal Game Adaptor* was an adaptor that helps to connect popular system specific controllers to other gaming systems to provide a familiar gaming experience on multiple systems for less money.

*6.4 Robotics*

The purpose of the *Marionette Puppet* Project was to create a fitness and fighting companion designed to replicate human body movements. This initial prototype started with the implementation of the puppet's arm.

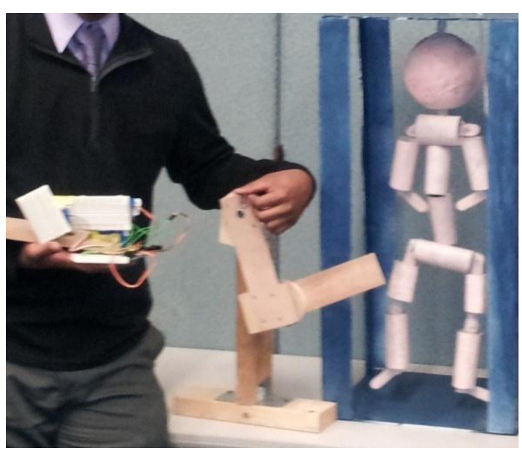

**Figure 4 Marionette Puppet (right) and Arm (left) Prototypes**

*Mind Control Car* was an Arduino micro-controller based car designed to move through EEG signals detected from a head mounted sensor.

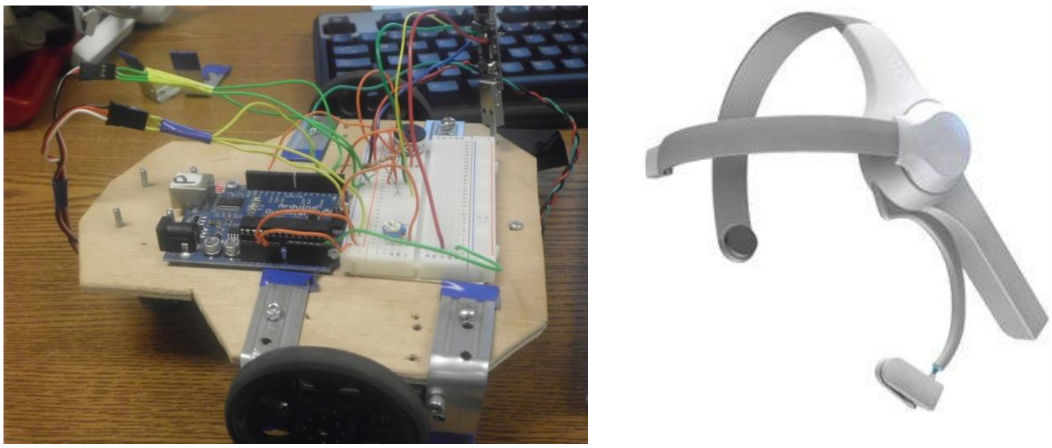

**Figure 5 Mind Control Car Prototype (left) and NeuroSky EEG Sensor (right)**

*6.5 Assistive Technology*

The *Briven* Project was a Braille tablet PC prototype designed using LEDs and Arduino-based controls to bridge the gap between seeing impaired and visually-able individuals.

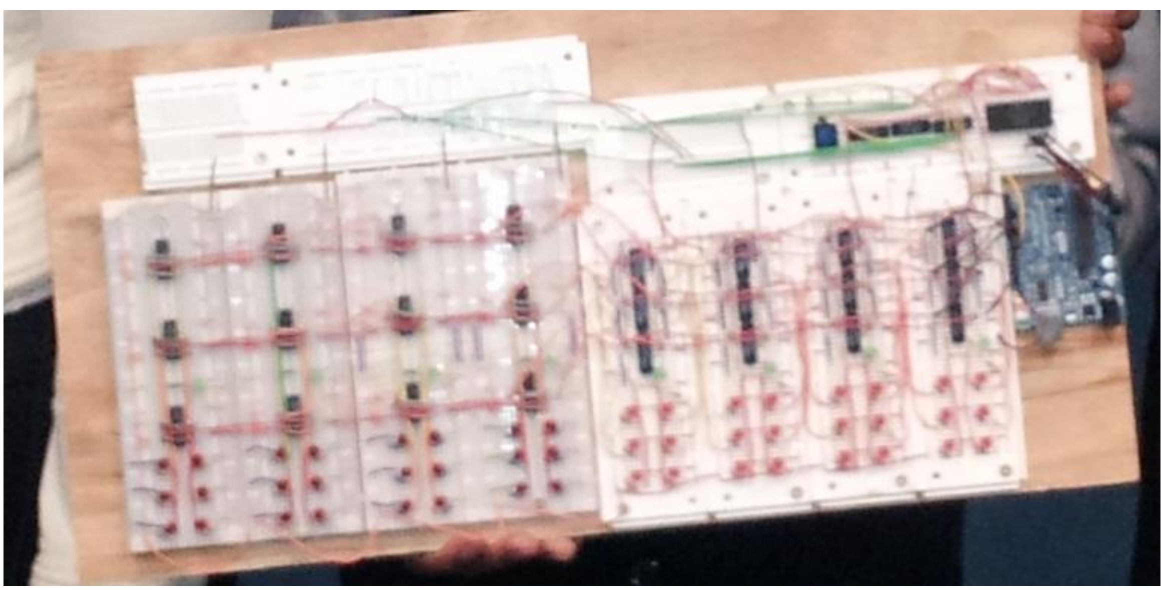

**Figure 6 Briven LED Braille Display Circuit**

The scope and complexity of students projects could not have been possible without regular attendance in the after school program. Thus, we owe the success of the program to the outstanding commitment of the students to these engaging projects in an open lab culture.

## 7 Program Outcomes

*7.1 Participant Retention*

After-school programs are often known for irregular student participation and engagement. We are happy to report that we have had tremendous success with attracting student to the I-3 Experience programs and retaining them across a school calendar year for 21 weeks of activities. The Spring 2011 and Summer 2012 programs were designed to be self contained but we invited students for each of these programs to participate in subsequent programs. From this effort we have been able to retain 3 and 4 students respectively from these programs. Starting in Fall 2011, we specifically recruited for students to participate in a series of 7-week programs but allowed students to opt-out at any point. Table 5 shows that over the span of the 21 week program that we only lost 11 of 39 students and thus retained 71.79% of our students across the three phases of the program. The 7 out of 11 students left the program due to conflicts with other after-school commitments when the day of the program changed or due to participation in seasonal athletics and have returned to participate in our summer camp or alumni program offerings.

**Table 5 Participant Retention by Session**

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 | Cohort #3 | Cohort #4 | Cohort #3 |
|---|---|---|---|---|---|---|---|---|
| | After-school | Summer | Imagine | Investigate I | Imagine | Investigate II | Investigate I | Innovate |
| all participants | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 | Winter 2012 | Spring 2012 | Spring 2012 |
| New | 17 | 12 | 9 | 16 | 10 | 0 | 0 | 0 |
| Returning | 0 | 3 | 0 | 4 | 0 | 21 | 9 | 19 |
| Attrition from previous phase | N/A | N/A | N/A | N/A | N/A | 8 | 1 | 2 |
| Total # | 17 | 15 | 29 | | 10 | 21 | 9 | 19 |

*7.2 Participants Enrolled in Computer Science Degree programs*

As of Summer 2011, we started collecting data on students' undergraduate degree choices. Therefore, we don't have data to report for Cohort #1. Overall, 39 juniors and seniors from Cohorts #2, 3, and 4 have participated in our program and have majored in or intend to major in CS (41.03%, n=16), STEM (15.38%, n=6), other (23.07%, n=9 ), and undecided (7.69%, n=3). These numbers suggest that the program has been successful in nurturing students' interest in Computer Science and STEM fields with 56.41% of students indicating these fields as their intended or enrolled degree decisions.

Table 6 indicates the number of juniors and seniors in each Cohort and their degree intentions. (Note: To prevent double counting individuals that participated in more than one cohort, the total number of juniors and seniors listed in Table 6 indicates only new students in these cohorts. Thus, four participants from Cohort #2 also participated in Cohort #3 but their degree decisions are only recorded under Cohort #2.)

Table 6 Participant Enrollment in CS Degree Programs (Juniors and Seniors during 2011-2012)

| | Cohort #1 | Cohort #2 | Cohort #3 | | Cohort #4 |
|---|---|---|---|---|---|
| | After-school | Summer | Imagine | Investigate I | Imagine |
| | Spring 2011 | Summer 2011 | Fall 2011 | Fall 2011 | Winter 2012 |
| Majoring in CS | No Data | 5 | | 3 | |
| Intention to Major in CS (applied) | No Data | 2 | | 6 | |
| Majoring in STEM | No Data | 3 | 2 | 0 | 1 |
| Other | No Data | 3 | 2 | 3 | 1 |
| Undecided | No Data | 1 | | 2 | |
| Total (Juniors & Seniors) | 11 | 14 | 4 | 14 | 2 |

*7.3 Student Awards and Recognition for the Computing Activities*

Participants in the I-3 Experience Programs have received awards and recognition for their projects through their participation in the AT&T Arduino Challenge, technical competitions, local and regional science fairs, and NCWIT Georgia Affiliate Aspiration Awards.

For the 2011 AT&T Arduino Competition, two teams from the I-3 Experience Programs Cohort #2 competed and won first (Cozy Coat) and second place (.007 Flybot).

For the 2012 AT&T Arduino Competition, six teams from Cohort #3 competed and won first (Briven), second (Music Tee), and third place (G-Sim).

In addition to winning first place at the 2011 AT&T Arduino Competition. 201, the Cozy Coat project won first place in the TN-WIC Undergraduate Research Competition. The two young women who designed the project were awarded free registration and an all expenses paid trips to Grace Hopper Celebration of Women in Computing Conference to continue their exploration of computing. The Cozy Coat project also won first place at one of the young women's high school science fair and second place in her county science fair.

Six students from Cohort #2 were awarded 2012 Georgia Affiliate NCWIT Aspiration Awards for their I-3 Projects and participation in computing activities at their schools.

**8 Student Surveys Results**

In the next section, we report on student feedback about the program. Unfortunately, we were unable to survey all program participants due to timing of the survey release and collection. Out of the 39 students who participated in Cohorts #3 and #4, we were able to collect survey responses for 22 of these students (Response Rate 56.41%).

*8.1 Student Perception of projects*

*8.1.1 Overall quality of projects*

Students rated the overall quality of their projects on a scale of 1 to 10 with one being low and ten being high. The average rating for projects was an 8.32 with a standard deviation of 1.69 by the students surveyed (n = 22). We also asked students to explain why they gave their projects the ratings that they did. Individuals (n =12) that rated their projects high (9 or 10) indicated one of the following reasons for their rating: enjoyment of project experience and interest in project, project was a good idea/amazing innovation, learned a lot in the process, put in a lot of hard work, enjoyed working with everyone. Individuals that rated their project at an 8 (n=4) thought their project was a good idea but were critical of their performance and the extent to which they were able to implement their project ideas. Individuals (n=6) that rated their project low (7 or below) indicated that despite good feedback about the project their group could have done a better job, they had a lot more to do on the project implementation, and they needed more time resources.

These ratings and explanations suggest that the experience of working on an interesting project is important to these students because of what they are able to learn, how they feel about themselves, what they created, and the people they worked with.

*8.1.2 Reward of Project*

While there are many ways to engage students in learning about computing and sustaining their interest, we chose student selected projects as a motivational tool and as a way of sustaining their interest throughout the 21 week program (an entire school year). As a facilitator in the program, it is clear that the students learned a tremendous amount working on their projects. The most common student responses when surveyed about the reward they received from working on the project were learning, completion, seeing progress/breakthroughs, and working with peers and facilitators. Students also indicated that they liked receiving recognition for their hard work, showing off their projects at competitions and showcases, and the overall experience. This suggests our use of the competitions and showcases was valuable motivation for getting students to bring their projects to completion. However, these findings suggest that students are really enjoying and rewarded by the journey and a sense of accomplishment aside from the recognition of others.

*8.2 Student Interest*

*8.2.1 Computing related activities since engaging in the program*

Since participating in the I-3 Experience programs, 28.5% of the surveyed students (6 out of 22) have participated in computer related activities. These activities included AP CS if offered at their school and one introductory programming at a local university. 31.8% of the surveyed students (7 out of 22) participated in a computer science related internship. These internships included fortune 100 corporations, summer Program facilitators at a local university outreach programs, and government IT offices. 31.8% of the surveyed students (7 out of 22) have started their own computing program at their school or in their communities. These outreach programs included robotics clubs, TSA, programming workshops, and Arduino clubs.

*8.2.2 What computing related activities would you like us to provide*

22 out of 22 surveyed participants wanted more programming instruction, assistance in preparing for the AP CS exam, and an opportunity to continue working on their projects. 72.7% of surveyed student (16 out of 22) reported being able to connect what they have learned from the program to what they are taught in school. Such connections include: math, programming courses and languages, research, presentation, public speaking, AP Biology and AP Statistics, debugging IT problems, assessment of peers, project prototyping, group collaboration, and increased initiative in group projects.

## 9 Summary of Program Impact Areas

There were several areas where we noticed that the program had impact. (1) Increased enrollment in Computer Science courses at their high schools. (2) Enrollment in Undergraduate Computer Science Programs. (3) Student Awards and recognition for their computing activities. (4) Starting their own CS programs or serving as student facilitators or community program organizers.

## 10 Programmatic Supports for successful implementation

In describing each of the I-3 phases we've alluded to a number of programmatic supports that we provided to the students to help them to develop their project ideas into prototypes and to increase and sustain their interest in computing. In this section, we will outline the supports that we provided the students with that were essential to running the I-3 programs and that we believe facilitated the impact we have reported here.

### *10.1 Facilities*

We had access to two large classrooms with movable tables and chairs. This allowed us to reconfigure the classroom based on needs of facilitators for conducting activities and the needs of the students to build their projects. One room only held tables, chairs, projector, and whiteboards. The second room was a computer lab with computers clustered in groups of two to allow student team workspace. Students were given full access in this room to project resources and computers.

### *10.2 Project Resources*

Students were provided with Arduinos, circuit elements, and wires for building circuits. AT&T donated more than 10 Arduino kits that students could use in the design of their prototypes. We provided wood, poster board, Styrofoam, boxes, etc for building their prototypes. They were also provided with additional resources to bring their ideas to life. For presentations and posters students were provided with poster boards, PowerPoint, Prezi, Google docs, Google sites, and Dropbox.

### *10.3 Facilitation & Mentorship*

We offered three types of program facilitation. The first and second author provided instruction and project mentorship throughout the year. Instruction was directed toward structured activities and tutorials on computer programming, introduction to different development platforms, and aspects of computing. The third author lead students in discussions of trending computing topics. The fourth was a technical expert and assisted with project mentorship.

All four authors mentored the students in conceptualizing, articulating, and developing their ideas into tangible prototypes. This process included meeting with the student teams, working with them to talk out their ideas and get them down on paper. It also involved recommending tools that they might want to develop with and features they might want to focus on or improve. This mentoring also involved helping them to develop prototypes. Scoping was a major component of helping students to actually have a prototype. This process also involved helping the students to manage conflicts in their groups, work distribution, helping students to identify and develop their skills and exercise their abilities. Lastly, the project mentorship involved helping students to create posters, presentations, and talk through demo sessions.

The third author mentored the students in preparing for college life and steps they needed to take to get scholarship. As a recent college grad she provided the students with someone closer to their age to connect with. This provided the students with a safe place to seek advice about personal struggles in school or in the program. This allowed us to have a student advocate that advised us on how the students perceived the program and places we needed to improve.

*10.4 Community*

Empowering our students with a taste of what college life has to offer is a key ingredient that cements the students experience and creates longevity in our CS program. Since our program ran concurrent with many of the college of computing student organizations and study groups, our high school students were able to see a healthy dose of college students at work and play. Some of our high school students had a chance to visit some of the college student organizations that met on the same nights as the I-3 Experience and on non-program days to learn more about the special computer science interest groups that were on campus. It also helped to have access to undergraduate CS students when troubleshooting student projects. Our undergraduate computing students were also invited to the I-3 Experience student showcases where they were sometimes called on to critique and evaluate student work. Our high school students greatly appreciated the investment that their bigger brothers and sisters in computer science provided. The college students often commented on the ambition and creativity the high school students demonstrated while on the other hand wishing they had such programs available when they were in high school. This network of students of all ages along with a staff that is truly invested in all of our student's quality of life draws our students to nurture their computer science aspirations. It has also challenged us to launch an I-3 Experience alumni program for students to continue to build on their computing experiences.

*10.5 Enrollment Services*

Since this program was offered through the administrative arm of a public computing department, we were able to offer additional support for students as they began applying to college. The department waived or reimbursed the application fee for students that participated in the program. Application workshops were offered to help students prepare their application essays, identify their activities and awards. Overnight campus visits were offered to the students to give them a taste of college life. During these overnights students attended classes with the college students, spent the night in the dorm, explored campus, ate in the dining hall, and met the college staff and advisors.

Many of the I-3 students were interested in enrolling in college so they participated in these programs to get a better understanding of college and college life. These programs helped students to understand that there was more to learn about CS and they ask our program staff these questions.

## 11 Conclusions

The I-3 Experience started off as a summer research opportunity for high school students who were interested in computing. Since its inception, it has developed into a place where students can gain valuable technology prototyping skills, programming skills, and written and oral communication skills. Students have enrolled in CS degree programs and developed their own outreach programs for younger students. Their confidence has increased in general and in CS specifically. To create the projects that these students envisioned required a dedicated and skilled staff and helpful students to break up their projects into small enough parts that they could have phases of success. It required the staff and the students to devise ways to overcome challenges that students met. The program has shown that student – facilitator relationships foster bonds that make students feel comfortable about exploring and sharing their interests, expectations, and desires for college education and their careers.

## 12 Next Steps

The program development team is currently exploring a new model where college undergrads lead the program for the purpose of scalability. This approach will explore the impact such a model has on the facilitator-student relationship, mentorship and project creation and completion. It also will explore the retention rate of students once they are in the second year of the program, I-3 Alumni, the success of first year CS Students, and the major choices of graduating seniors.

## 13 References

[1] Ericson, B. & McKlin, T. (2012) Effective and sustainable computing summer camps. In *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education* (SIGCSE '12). ACM, New York, NY, USA, 289-294. http://doi.acm.org/10.1145/2157136.2157223