CodeIT Day: Breaking Stereotypes and Feeding the STEM Pipeline

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Abstract

It has almost become common knowledge that there are not enough Computer Science graduates to fill the available computing related job openings. Just as common is the knowledge that the current computing workforce is not ethnically diverse and has a male to female ratio that is disproportionate to the general population. Many researchers have argued that the low number of students in the computing pipeline, a track from K12 to college to a computing career, is a result of a lack of exposure to computing and computing careers. When attempting to explain the low numbers of women and people of color in the pipeline, researchers believe that a lack of role models of color and negative stereotypes about scientists and engineers play a large role. In this paper, we describe CodeIT Day, an outreach event for middle school students created to address both of the previously mentioned issues.

Keywords

Outreach; STEM pipeline; stereotypes; computer science education

1. Introduction

In today's world, technology is evolving and advancing at a rapid pace. By 2018, the Bureau of Labor Statistics anticipates that there will be more than 3 million jobs available in the STEM fields [1]. The increase in demand for competent and skilled workers led to the establishment of the Educate to Innovate initiative by President Obama's administration in November 2009 [2]. The initiative seeks to provide better STEM education preparation, broaden participation by increasing diversity in the field, and build a coalition with the private sector, amongst other goals. Overall, this initiative attempts to address current problems in the STEM pipeline that affects the entrance and retention of students in the field**.**

Secondary education preparation is key in preparing students to enter the pipeline as they enter high school. Researchers have followed students as they matriculated through high school. Reports have shown that students' decisions to pursue STEM careers are positively influenced by taking more advanced courses, personal interest, and having an active learning experience [3,4]. Nevertheless, roughly half of the students who pursue a STEM major actually finish their degree. Specifically, 48% of students pursuing a bachelor's in STEM fields, between 2003 and 2009, left their respective major by 2009 [5]. Limited exposure to STEM courses early in the college career along with poor performance in these courses are some reasons why students leave their STEM program [6-8]. In the case of women and minority students, discrimination and lack of role models serve as additional factors that contribute to their departure [9].

The underrepresentation of women and minorities in the STEM pipeline is another cause for concern. In 2012, women were awarded 50.4% of science and engineering bachelor's degrees, including biological sciences. Only 19.2% and 18.2% of these degrees were in engineering and computer sciences respectively. Minority women were only awarded 11.2% of science and engineering degrees [10]. One cause for this disparity is the stereotypical portrayal of scientists, engineers and mathematicians. In a study conducted by the US Department of Commerce, between 1994 and 1998,75% of the actors that portrayed scientists in prime time television, were Caucasian men [11]. There is a general consensus that STEM is a male dominated field. Some of the "masculine" traits exhibited in STEM, such as independence, can cause females to underestimate their abilities and lower their expectations of success [12]. Furthermore, STEM scientists can often be depicted as anti-social and "nerdy" and only as Caucasian men. The media does very little to dispel this myth. This imagery conveys the message to girls and minority children that there are not people who look like them in the STEM fields. There is also limited exposure of successful scientists and engineers who come from underrepresented backgrounds for minority students to follow. At the University of Binghamton, it has been shown that there is a positive correlation between the number of female instructors in STEM courses with the persistence of females majoring in the field [13].

In order to provide students with STEM role models and to counter the narrative about Computer Science and computer scientists, we created CodeIT Day. This day-long event utilizes a multi-racial group of men and women to teach robotics and Computer Science.

This paper will discuss the purpose of CodeIT Day and the design of the intensive all-day, hands-on workshop. We will discuss the lessons that we have learned and changes that we will make to future workshops.

2. CodeIT Day Origins and Purpose

In the Fall of 2012, graduate students at Clemson University, including two of the authors, came together to find a community service project. These students were particularly interested in becoming involved in activities that would broaden participation in and change perceptions of computing fields. When they found no local programs of interest, they decided to create their own. This new program was eventually named CodeIT Day.

CodeIT Day is a workshop designed for middle and high school students. During this daylong workshop, students are introduced to Computer Science in a fun, hands-on manner. CodeIT Day enables students to learn, build,and program various interactive technologies with the guidance of graduate and undergraduate students. Many of these activities require the students to be grouped into teams. At the end of the day, students present their projects to a larger audience composed of family and friends. Through this experience, students become excited about computing, learn to work as a member of a team, and gain experience presenting their work.

CodeIT Day was not only created to introduce students to computer science concepts, but also to break down these stereotypes and to show students what computer scientists can look like. We

purposefully selected a diverse group of volunteers to help dispel the common misconception that only one kind of person can be successful in Computer Science.

3. CodeIT Day

In this section, we give a general CodeIT Day overview and describe each day-long workshop in further detail. We also explain our student demographics, how participants are recruited, our volunteers, the technologies employed, and the structure of the workshops.

3.1 The Students

In order to recruit participants, we contacted principals and guidance counselors at local schools, community centers and local alumni chapters of several fraternities and sororities. The contact person at each school or organization disseminated information about CodeIT Day by mail, email, and word of mouth. To date, over 100 students have participated in CodeIT Day events. Amongst these participants, approximately 21% have been girls and 33% were from underrepresented groups. Some of these participants had medical, cognitive, and physical challenges, while others came from underserved and/or socio-economically disadvantaged communities.

3.2 The Volunteers

The volunteers for CodeIT Day were composed of graduate and undergraduate students with backgrounds in computing. These students were recruited from the Universities in which the authors were enrolled using email, promotional flyers, and word of mouth. Most of the volunteers belonged to groups who are underrepresented in computing fields including women, African Americans and Latino/Hispanic Americans. While the undergraduate volunteers primarily served as teaching assistants, the graduate volunteers served as lead instructors and assistants. Each lead instructor created and taught a lesson for their particular technology.

The volunteers also served as mentors. For the most part, these volunteers were not embodiments of the stereotypical computer scientist. Since this event was many of the student's first real experience with Computer Science, the intent was to broaden the students' perception of Computer Science as well as the people who work in the field.. For instance, this event would show the participants that a computer scientist could be either a man or a woman, a representative from any race or ethnic background, and someone who has interests outside of computing. We selected a diverse set of volunteers for this particular reason. Overall, it was our goal to show students that computer science can be for everyone.

Figure 1. CodeIT Day Volunteers

3.3 The Technologies

Since the first CodeIT Day event, seven technologies (Lego Mindstorms, Lego WeDo, PicoCricket, Makey Makey with Scratch, and Nao Robots with Choreographe) have been incorporated into the program.

Lego Mindstorms is a robotics construction set that gives students the ability to create and command their own Lego robot using programming techniques. This technology enables students to implement robots that move, speak, listen and see by using motors and sensors. Lego WeDo introduces students to robotics by using blocks of Legos and related constructs for building and developing different objects as solutions. Sensors and motors are used to manipulate and control the developed objects. PicoCricket is a small computer that can be programmed to control connected motors, sensors, sounds and lights, much like the WeDo.

Makey Makey is an invention kit (including alligator clips) that turns everyday, conductive objects into touchpads. With Makey Makey, students can create anything from works of art to game controllers and more. Scratch is a drag and drop interactive programming interface that allows students to create interactive stories, animations, and games and interfaces with Makey Makey. The Nao Robots are humanoid robots made programmable with the Choreographe software. Students can use Choreographe to create, edit, simulate and test movements to control the Naos.

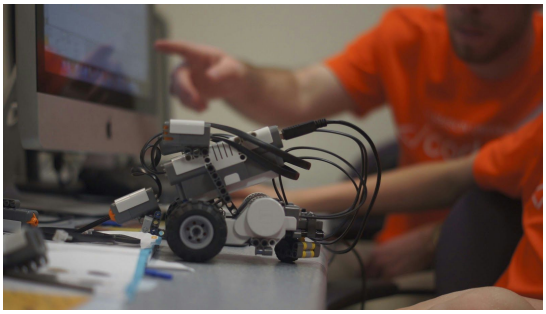

Figure 2. Participant and Volunteer debugging a Lego MindStorms project

3.4 The Workshop Structure

Students were divided into groups (three groups for CodeIT Day 2013-2014 and two groups for CodeIT Day 2015) and subdivided into coding teams (two or three students per team) prior to their arrival. We separated siblings and students from the same school by putting them into separate groups and on different teams. We also divided the female students equally between groups. Each group contained eight coding teams. Each team and group remained together for the entire day. CodeIT Days 2013 and 2014, each featured three different technologies. Each group was assigned one technology to use for the entire day. CodeIT Day 2015 featured two technologies. Each group was able to use both technologies for half of the day.

Upon arrival, we provided students with a t-shirt, name tag and a hot breakfast. Then we introduced students to the staff and gave them the rules of the day which were: have fun, ask questions, work hard and be a great teammate. The students were then sent to their respective classrooms. The course structure was the same for each group. First, students were introduced to the software that controlled their respective technology. Second, students were able to practice different programming techniques and computing concepts using that software. Next, students were encouraged to brainstorm with their partner(s) about what they wanted to build, how they wanted it to operate, and finally how they would achieve these goals. After brainstorming, the students proceeded to build and program their technology. When students believed they were finished building and programming, they went into testing mode. During testing, they executed their code to make sure everything worked as expected. If something went wrong, they had the opportunity to go back and fix the problem. Finally, once students successfully tested their projects, they were ready to practice for their final presentations. When it was their turn to present, students introduced themselves and discussed everything that they were able to accomplish during the day. They then described their project before giving a demonstration.

3.4.1 CodeIT Day 2013

The first CodeIT Day was hosted on the campus of Clemson University in the Spring of 2013. For this event, we partnered with the School of Education to leverage their experience hosting youth camps and their sizeable network. Students were recruited from public, private and home

schools in Greenville and Pickens Counties via email and the personal communications of our School of Education contact.

There were 21 participants in the first CodeIT Day workshop. Out of this group, there were eight girls (seven White/Caucasian and one South Asian). There were also five boys who were members of underrepresented groups (one Asian and four African-American).

Lego WeDo, PicoCricket and Makey Makey with Scratch were the selected technologies for CodeIT Day 2013. Students were separated into three groups, one for each technology, and were then divided into two or three person teams. Each group was assigned one of the three technologies. Students learned to used their one assigned technology, following the previously described course structure, over the course of the day.

3.4.2 CodeIT Day 2014

CodeIT Day 2014 was also hosted on the campus of Clemson University in the Spring of 2014. Because we expected the number of applicants to double, we scheduled two CodeIT Day workshops, one on Saturday and another on Sunday, with different sets of students. To recruit, we sent notifications to the same networks that were utilized in 2013. We also sent invitations to all previous participants and to their schools if they were not on the original list.

In total, there were 40 participants across the two CodeIT Day workshops. Nine of the participants were girls. Six of the girls were White/Caucasian, one was of South Asian descent and two were African-American. Additionally, there were four and five African-American and Hispanic/Latino boys, respectively.

For both CodeIT Day 2014 workshops, we used Lego Mindstorms, Lego WeDo, and Makey Makey with Scratch. For each workshop, Saturday and Sunday, students were divided into groups and teams and were assigned technologies in the same manner that was described in the description of CodeIT Day 2013.

3.4.3 CodeIT Day 2015

The most recent CodeIT Day was hosted on the campus of the University of Florida in Gainesville, Florida. To recruit students, information letters were sent to school counselors in Gainesville and the surrounding counties. In an attempt to persuade more minority students to attend, two of the authors visited a local middle school where the majority of the student population was African American. While at the school, the authors made an announcement on the morning announcements, spoke with a Vice Principal and a counselor, and spoke with the school's science and technology club.

28 students were in attendance for CodeIT Day 2015. Of the 28 students, there were two girls, one of whom was African-American and the other was Hispanic/Latino. There were nine boys who were ethnic minorities; three were African-American, five were Hispanic/Latino and one was of South Asian descent.

For CodeIT Day 2015, we used two technologies, Lego Mindstorms and Nao Robots, instead of three. We also allowed students to have the opportunity to switch technologies mid-way through the day. In order to accommodate the changes, we first divided the students into two groups, Group A and Group B. Group A began in the Nao Robot class, while Group B started with Lego Mindstorms. They followed the previously mentioned course structure for the first half of the day. After lunch, students would switch into the other technology for the remainder of the day.

3.5 A Focus on Collaboration and Communication

A secondary goal of CodeIT Day was to show students that computer scientists can also work in teams. We grouped the students into teams of two or three; depending on the number of participants. In some instances there was an initial power struggle between the members of the groups. We noticed that once they began working on their projects, they began to find their own roles, delegate tasks, and share the work without being told or coached. As the day progressed, students began to form a community composed of, not only their two or three member project team but their entire technology group as well. While students were assigned to "WeDo" or "Makey Makey", they became "Team WeDO!" and "Team Makey Makey", each with their own team chant. They wanted to see teammates succeed and collectively outperform the other technology groups.

Figure 3. CodeIT Day Participants in a TeamWeDO! huddle

Some of this intra-technology group camaraderie may have happened, in part, because of final presentations at the end of the day. Students knew that during the presentations, each technology group would be called to the front and each team would present their project to the parents, and to the other groups. Although they knew no prize would be given for the best project and presentation, students prepared and worked on their demo setup as if their reputations were on the line.

Although their focus was on the competition between one another, the students learned and practiced valuable skills by working with and presenting in front of one another. First, as they were learning to use the technology specific integrated development environments (IDE), students were introduced to pair programming; one student had control over the keyboard and

mouse while the other gave guidance and instructions about what to type [14]. Second, the students practiced working in self-regulated teams/partnerships. Although the program staff assigned all teams and volunteers monitored what the students were doing, each group designed and developed their own project. Without much input from volunteers, the groups were able to practice handling internal conflict, managing their time, and dividing tasks in a way that would help them create the best project possible. Lastly, students learned to present and describe their work. During the final presentations, each student was asked to introduce him/herself. Then, each team was asked to discuss what they learned, what they built, how they built it, the challenges they faced, and how they were able to overcome them. In order to prepare for this presentation, students needed to reflect on their day to evaluate what they did and did not do well. They also needed to practice to ensure that they would be able to articulate their thoughts in a clear and concise manner.

Working in a team and giving oral presentations are not typically skills that are targeted during Computer Science outreach events. However, it was our goal, in addition to breaking stereotypes, to help students hone skills that they could use, no matter what field they chose. Based on student and parent responses to the program, we believe we accomplished that goal.

4. Participant and Parent Responses

Because CodeIT Day is not considered a research project, we do not collect survey or longitudinal data. We do however collect video and audio recorded participant interviews and unsolicited parent/guardian emails. We also track the number of times that a student has attended a CodeIT Day event.

When reviewing the interviews, we learned that many of the students came to CodeIT Day not knowing what to expect. They were under the assumption that they were going to learn *something* about computer science and/or programming. One student stated “I thought I was coming here to see a lecture and then we were going to type some code and build a website”. Though he would not have minded a lecture, he was glad to “work with cool robots”.

While newcomers did not know what to expect, previous participants had some insight to the format of the event, and were glad to be able to return. They exhibited excitement and were eager to share stories from their last CodeIT Day experience. One returning female student stated, “Programming is so cool because you can put everything together and make things happen. It’s fun to see what you made come to life.”

Once the students were taught basic programming concepts related to their specific software, they were eager to explore and begin constructing and programming their technologies. They were also excited to present their final projects to their families and new friends at the end of the day. One student enjoyed their experience so much, that he went home and installed the free Scratch software on his personal computer to continue practicing his programming skills. When asked if they would return to CodeIT Day, every student responded with their own versions of an emphatic “Yes”!

The participants were not the only ones impressed by what they experienced at CodeIT Day. In an email to the department chair, one father stated “My two kids, a son (14) and a daughter (11) took part in this event. They had a terrific time, and my wife and I were privileged to get to see the final presentation of the kids' work at the end of the day. It was extremely impressive.” He went on to say “this was, without a doubt, the most inspiring demonstration of engaged learning and effective outreach that I have seen in years. Those...students did the University proud, and gave a valuable gift to a bunch of kids in the process.”

5. Lessons Learned

Since the first CodeIT Day event, we have conducted three (two in 2014, one in 2015) additional full workshops and many smaller workshops. In that time, we have been able to resolve several issues. The first challenge we faced was selecting the right kind of volunteer. Although students were there to learn, we wanted our students to have fun. Some of the selected lead instructors wanted to be sure the students had a great time. Though the students in these classes did have fun, we noticed that they spent more time laughing than they did working. Although they managed to finish their projects, the students found themselves scrambling to complete their projects after lunch.

Some lead instructors were very interactive with the students, while others were not as engaging. Upon encountering instructors who tended to be less interactive, the participants were found to be more serious and less playful. In order to strike the right balance, we formed our teams differently. When selecting three volunteers to work in a class, we were sure to match great teachers with people who would be sure to keep the atmosphere fun, lively, and interactive.

When it was time to decide on their projects, we faced three similar but related issues; students did not know what to create, they were overly ambitious, or they were overly cautious. In order to rectify this situation, volunteers were instructed to give the groups in their class five project options that they could modify and make their own. From this set of five, each group would select a project. Providing students with options gave them starting points and a set of constraints, in addition to the ability to modify allowed them to be creative.

Another issue related to project selection was that older and more experienced students would finish their projects early and get bored. To remedy this issue, we placed all the older students in the class with the most challenging technology and offered them either difficult projects or a series of smaller projects.

For the first three CodeIT Day events, students conducted live demonstrations during their final presentations. During the presentations, we encountered several problems with the. We noticed that some teams would have trouble getting their projects to run properly. Another issue was that many of the technologies required a connection to a computer, which made it difficult for people far away to see what was happening. To remedy that problem, students at CodeIT Day 2015

recorded their projects and showed a video during their presentations instead of doing live demonstration.

A second issue that arose during final presentations was that some students were upset that they were unable to utilize all of the technologies. While they enjoyed their own projects, they were interested in using the tools that the other students used. This year, it was decided that all students would experience two of the technologies instead of one. This way, students were able to work on multiple projects over the course of the day, which hopefully added to their excitement and led to less boredom.

A final lesson from CodeIT Day is that a 10+ hour day is too long. The students arrive as early as 7:30 am and do not leave campus until after 6:00 pm. After lunch, the students, especially the younger students began to get restless and inattentive. It was often difficult to get them to stay on task and to continue working well with one another. Our volunteers also became fatigued and began to lose the enthusiasm that they had at the beginning of the day. From now on, CodeIT Day will begin at 9:00 am and end at 3:00 pm.

6. Conclusions And Future Work

We created CodeIT Day as way to give back to the community, expose and excite students about Computer Science, and combat stereotypical perceptions about people who study this field. If positive parental feedback and the students' excitement are strong indicators that can measure success, we believe that our goals were accomplished. As a result of the four CodeIT Day workshops described in this article and several smaller sessions, there are over 100 students who are excited about computing and are headed towards the STEM pipeline.

Although we welcome all students who are interested to participate in CodeIT Day, one of our goals is to help broaden participation of women and minorities. In the future, we want to increase the number of women and underrepresented minorities who participate in CodeIT Day. Although we were able to target a school with a large minority student population, we still were unable to get as many participants as we anticipated. We want to continue to target schools with this demographic. As we move forward, we will include minority male students when we visit schools to recruit. We believe this might show young men that CodeIT Day is not just for girls (the current recruiting team is made up of all women). We will also provide demonstrations of the technologies that students might encounter at a CodeIT Day workshop to generate more excitement. We also want to recruit within the community at places like Girl Scout group meetings (to reach more young girls), churches, and community centers. We will make an effort to speak with not only the children, but to their parents as well. This could help ensure that the information about CodeIT Day is not only in the hands of the students.

Finally, we intend to introduce a new technology, the Arduino into the program. The Arduino is a small programmable computer that interacts with the world through electronic sensors, lights and motors. The addition of this new technology will allow for us to employ projects that are more robust, challenging, and interesting.

7. Acknowledgements

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