Recruiting STEM Students into Middle/High School Teaching

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Abstract

The STEM acronym – which stands for Science, Technology, Engineering and Mathematics – has become popular and is commonly used in both the media and education arena. The STEM subjects are considered to be the focal point of attention to a 21st century education. Most colleges and universities, regardless of their Carnegie ranking, offer outreach programs in STEM, which are designed to draw student interest to these important fields. Recently, the University System of Georgia has approved XXX University to offer STEM tracks. The degrees offered include: BS Civil Engineering Technology (Technology Education track), BS Electronics Engineering Technology (Technology Education Track), BS Mathematics (Secondary Teacher Education track) and BS Biology (Secondary Teacher Education Track). To enhance the newly formed programs, XXX University received a five year Robert Noyce Scholarship grant to recruit, mentor, educate, and certify students to become highly qualified STEM middle school and high school teachers to meet the workforce shortages in this area of national need. This paper will describe the learning methodologies introduced to potential student teachers, as well as the specific lesson plans, hands-on activities selected to encourage interest in teaching Science, Technology, Engineering, and Mathematics (STEM). At XXX University four week summer program was conducted for teaching STEM activities and lessons plans geared towards Middle/High School Teaching. The main focus of the summer enrichment program was to encourage students to enter the STEM teaching profession as Middle/High School teachers. Three primary areas selected to build enthusiasm for teaching STEM were Electronics Engineering Technology, Civil Engineering Technology and Mathematics.

Introduction

The demand for Science, Technology, Engineering and Mathematics (STEM) is expected to grow at a phenomenal rate as compared to the non-STEM (17% from 2008 to 2018 compared to 9.8%).[1] Furthermore, employers claim that there shortages of qualified workers in STEM areas.[2] National Science Board identifies that the students will be required to develop their STEM capabilities at higher level as compared to the levels in the past, even for low skilled jobs.[3] To meet the demand for the STEM work force, there is a dire need to expand the STEM pipeline by increasing the number of STEM graduates. To stay competitive in the global market in STEM areas, research shows that we need to make sure that US students have needed STEM skills every step of the way from K to 8, high school to college which is supported by high quality STEM education.[4] Interventions needed to fill in the gaps are meant to boost K-12 STEM teacher quality education through: awareness among students of the importance of STEM careers with special emphasis on teaching careers, improving curriculum which will include STEM pedagogies and learning materials, and establishing more rigorous STEM standards via expanding requirements for STEM courses, more testing and assessment.[5, 6] The backbone to increase the STEM graduates is to increase the high quality STEM teachers.

In 2015, the National Science Foundation (NSF) awarded XXX University the Robert Noyce Scholarship program grant to foster teaching career paths for middle and high school teachers to meet the demand of STEM teachers in the Savannah Chatham County Public School System (SCCPSS). The grant offers various initiatives to attract mathematics and engineering students into STEM Middle and High School teaching careers through partnerships with other institutions, educational courses, scholarship, and summer internship program and outreach activities. Through the Robert Noyce Scholarship program, XXX University in partnership with XXX Technical College and SCCPSS prepares at least twenty-eight (28) undergraduate mathematics and engineering majors and eight STEM professional to become certified middle school or high school teachers of mathematics and/or science grades (6-12). Working with regional high schools, XXX Technical College, and STEM employers, the project team recruits high-quality students and professionals interested in STEM-focused teaching careers, and the program provides a combination of scholarships/stipends, summer teaching internships, structured field observation experiences, and rigorous teacher-preparation curriculum to prepare them to be successful, long-term members of the STEM teaching faculty in the Savannah Chatham County Public School System (SCCPSS) and beyond. In partnership with SCCPSS, the project team will provide post-graduation mentoring and follow-up to ensure a successful transition to teaching and improve retention. Specific elements of the program include the following:

1. Launching an aggressive recruitment plan for talented math and engineering majors to pursue teaching careers in 6 -12 secondary schools;
2. Implementing a comprehensive STEM teacher training program;
3. Providing Summer Educational Internship Program (SEIP) to rising sophomores;
4. Providing Field Observation Experiences for sophomores;
5. Providing $10,000 scholarships to talented math and engineering juniors and seniors to pursue teaching career by acquiring education training through XXX University teacher education math, civil, and electronics engineering technology programs;
6. Providing $10,000 stipends for STEM professionals or recent STEM graduates to become teachers;
7. Enhancing the local district's teacher mentoring and professional development program to improve teacher performance and retention.

The XXX University/XXX Technical College Noyce Teacher Scholarship Program recruits from a predominantly minority population (XXX University's student population is 94% African American), and the target school district has a high proportion of minority students and faculty compared to other districts in the region and state. The program prepares high quality teachers from underrepresented groups who will be well positioned to serve as role models in STEM for students from similar backgrounds. XXX University's activities as a Historically Black University will also contribute to a broader understanding of how teacher preparation programs can be tailored to reach and prepare African-American students for successful teaching careers through similar institutions. Dissemination activities will focus on sharing program processes and results with other institutions in Georgia and with other Historically Black Colleges and Universities nationwide. In particular, the project goal is to increase the number of high quality mathematics and technology education-certified teachers prepared to teach in a high-need school district by implementing a targeted recruitment, training, and mentoring program for students and professionals in mathematics, civil engineering technology, and electrical engineering technology who wish to enter the teaching profession. This project goal is supported by the following two objectives:

1. To train, certify, place, and mentor 28 STEM teachers from among 100+ undergraduate mathematics, civil engineering technology, and electrical engineering technology majors recruited to participate in Noyce program activities.
2. To train, certify, place, and mentor 10 STEM teachers recruited from a pool of interested STEM professionals who hold a baccalaureate, master's, or doctoral degree in science, mathematics, computer science, or engineering

This paper will describe the four week Summer Education Internship program which provides opportunities to the students who are considering teaching careers to get exposure to the field of teaching so that they will make the decision to enter the program based on their passion and not just based on the scholarship. This summer internship opportunity will also address an ongoing policy debate about whether offering scholarship funds to undergraduate students is an effective means of recruiting them into teaching.[7, 8]

Summer Educational Internship Program (SEIP)

The XXX University/ XXX Technical College team developed and implemented a four-week Summer Educational Internship Program (SEIP) for math and engineering rising sophomore students to engage them in teaching experiences with students in grades 4-8. Rising juniors may also participate, but their scholarship eligibility will be limited to the senior year. SEIP offered 14 internships (9 from XXX University, 1 STEM professional and 4 from XXX Technical College) at the rate of $1,000 per participant. In the first week, interns learned about teaching methodologies in math and technology standards. In the last three weeks, participants worked on design and implementation of teaching course plans for math and engineering (technology) activities and applied teaching methodologies in classroom settings with students in grades 4-8 at the Oglethorpe Academy. Table 1 shows the SEIP activities. The SEIP requires that the students must participate in field teaching experience so that their expectations for teaching will be realistic and they will remain in the teaching field for the long run.

Formative Lesson Plans

While the shortage of teachers in the area of STEM is well recognized, there are still relatively few graduating high school seniors or college freshmen students electing to pursue a bachelor’s degree in STEM teaching. SEIP offers an opportunity to college students and STEM professional to develop interest in teaching. One motivating factor for creating formative lesson plans was a need to provide a learning experience to the participants which furthermore will benefit the end user (Elementary/Middle school students) to understand STEM concepts (Engineering/Mathematics) [9]. In the first week, lesson plans were created in the areas of Civil Engineering Technology, Electronics Engineering and Mathematics. Numerous factors related to content and format benchmarks were documented prior to the development of lesson plans. The most important are emphasized below, along with a few descriptive remarks.

1. Each lesson plan must be grade level suitable: Lesson plans were separated into elementary and middle school levels. Hence activities were designed according to the

grade level. A Professor from the School of Teacher Education who is certified educator played an instrumental role in the development of lesson plans. State curricular requirements for each grade level were integrated into the lesson plans.

2. Each lesson plan must be precise: In addition to being grade level appropriate, the lesson plans were planned to integrate engineering and mathematics concepts and principles. Mentors from Engineering and Mathematics worked with the students to exchange ideas in the development of lesson plans and hands-on activities.
3. Materials needed to implement lesson plans: Hands-on activities were designed to keep the cost of the materials to implement hands-on activities at a low level. Civil and Electronics Engineering Technology material was provided by the university and the computer support was provided by the academy.
4. Lesson plan were self-contained: Interns were required to develop lesson plan with their respective mentors. The lesson plans were well documented and printed so that the students can follow the lesson plan during their respective teaching assignment.

Table 1: SEIP Activities

Week 1 5/18/2015 XXX University	Week 2 5/26/2015 XXX University Student mentoring	Week 3 6/1/2015 Oglethorpe Academy Technology Week Elementary School students	Week 4 6/6/2015 Oglethorpe Academy Middle School students
Day 1 Orientation Dr. Mulvanity, Mr. Dean and NOYCE/SOTE team	Day 1 Work with the discipline area mentors to develop math and engineering course plans	Day 1 10:00 -12:00PM Hands-On Activities/Labs in Engineering and Math 12:00PM -1:00PM Mentoring/ Assessment	Day 1 8-9 Planning 9-10 Lecture 10-1200PM Hands-on activities/Labs 1200PM -100PM Mentoring/ Assessment
Day 2 Planning lesson plans under how to design activities	Day 2 Work with the discipline area mentors to develop math and engineering course plans	Day 2 10:00 -12:00PM Hands-On Activities/Labs in Engineering and Math 12:00PM -1:00PM Mentoring/ Assessment	Day 2 8-9 Planning 9-10 Lecture 10-1200PM Hands-on activities/Labs 1200PM -100PM Mentoring/ Assessment
Day 3 How to manage learning through activities	Day 3 Work with the discipline area mentors to develop math and engineering course plans	Day 3 10:00 -12:00PM Hands-On Activities/Labs in Engineering and Math 12:00PM -1:00PM Mentoring/ Assessment	Day 3 8-9 Planning 9-10 Lecture 10-1200PM Hands-on activities/Labs 1200PM -100PM Mentoring/ Assessment
Day 4 Instruction/ Teaching Methodologies	Day 4 Work with the discipline area mentors to develop math and engineering course plans	Day 4 10:00 -12:00PM Hands-On Activities/Labs in Engineering and Math 12:00PM -1:00PM Mentoring/ Assessment	Day 4 8-9 Planning 9-10 Lecture 10-1200PM Hands-on activities/Labs 1200PM -100PM Mentoring/ Assessment
Day 5 Implementation/ Assessment	Day 5 Work with the discipline area mentors to develop math and engineering course plans	Day 5 10:00 -12:00PM Hands-On Activities/Labs in Engineering and Math 12:00PM -1:00PM Mentoring/ Assessment	Day 5 8-9 Planning 9-10 Lecture 10-1200PM Hands-on activities/Labs 1200PM -100PM Mentoring/ Assessment

Structure of a Lesson Plans

Lesson plans were structured based on the uniform approach for Civil Engineering Technology, Electronics Engineering Technology and Mathematics. The layout was designed to assist student interns to design and develop the lesson plans with heavy emphasis on hands-on activities. A typical lesson was structured in the following sections: Central Focus, Objectives, Activities, Prior Academic Knowledge, Materials required, and Instructor's Assessment and Student Learning Outcomes. The following paragraphs will present sample lesson plan for technology session.

Central Focus

It was the goal of the technology lesson to educate the students on the fundamentals of computer programming. In order to do this, a simple block based software called SNAP was utilized. This lesson entailed that the students learn five basic concepts in the field of computer programming. These concepts are variables, control structures, data structures, syntax, and tools.

Variable: A variable is a storage location associated with a name. The variable stores information or a value. In the SNAP software the most basic variable was the sprite and the background. These variables stored images made by the students. The sprites and backgrounds could be named to fit the context of the image and later could be called upon in order to have them perform actions. The sprites commonly held the most amount of information such as scripts, movements, coordinates, and even sound files.

Control structures: A control structure is a block of programming that analyzes the script and determines in which direction the program should be performed. The workflow of the programs in SNAP followed a top down format where command blocks were stacked on top of each other. Whatever command structure rested upon the rest was performed first.

Data structure: A data structure is certain way of storing and organizing information so that it can be used efficiently. In the SNAP program this concept was demonstrated most certainly by binding keys to an action instead of completely coding the movements of a sprite. This way the data structure was simplistic and pragmatic.

Syntax: Each programming language has a syntax which is a set of rules that dictate which combinations of symbols are considered "grammatically" correct. This concept is demonstrated in SNAP when the student is asked to have their sprite speak. In this command structure the student is asked for the time period that the sprite will speak. The program cannot execute if the student inputs letters instead of numbers.

Tools: Tools are simply software that makes programming faster and easier. The students were shown the contrast between the original and much more complex coding which is the base of the SNAP software. The student will understand that SNAP is a tool which simplifies this process.

Objectives

The students were to successfully construct programs that performed specific tasks in the SNAP software.[10] Each task largely followed the same process. The students were to create a background and a sprite. The sprite was to perform actions using select commands chosen from super-categories located in the menu. When a student was able to manipulate the sprite and the environment in the desired way instructed by the teacher, it was demonstrated that the student had fulfilled the objective of the lesson.

Activities

Below is the lesson plan in terms of activities in chronological order. Each of these activities introduced the students to new commands and problems to be solved.

1. Upon entering the classroom, each student was seated in front of a computer and asked to go to the Snap website. Once each student was directed to the website, they were to login under one account previously made. The students would be presented with the default screen of the Snap software where the block based compiler was displayed.
2. The teacher asked the students to introduce themselves by creating a sprite of themselves in the SNAP application and then use the appropriate commands in order for their sprites to say something interesting about the student when the correct key was pressed. The teacher demonstrated how the task was to be done from his/her own computer. The computer's screen was shown in real-time from a projector.
3. The teacher then asked the students to load a pre-programmed environment from a drop menu. In this program, the backgrounds had already been made. The backgrounds were of each kind of zone which an animal may thrive - the sky, the ocean, the forest, or the desert. The teacher asked students to create a sprite of their favorite animal or to make a completely new animal. Once a student had finished creating their animal in the sprite creator he/she was to come to the front of the classroom and record themselves imitating their animal. The recording was stored as a file and implemented into the program so that when a specific key was pressed the child's imitation would play.
4. The students then were shown how to create animations in the SNAP software using the costume super category. The students had to create the illusion of movement by creating multiple costumes for one sprite and then have those costumes be displayed every half second in a specific order. The students also looped this process by using control commands.
5. Another pre-programmed environment was opened by the students. This time, an unfinished game was opened. The teacher asked the students to attempt to play the game. The game consisted of a car navigating a maze to reach the end destination or goal. The problem was that the car could not retrace its path because the left arrow key would not respond. Also, the walls of the level were too narrow and when touched, the car would be sent back to the beginning. The teacher presented the move function to the students and explained the importance of x and y coordinates. The teacher also explained how to bind an action to the left arrow key.

Prior Academic Knowledge

The students needed only basic knowledge and skills to complete the assignments. They must be able to read, perform arithmetic, navigate computer interfaces, and other basic skills. They must know the English language, the number system, and the basic functions of a PC.

Materials Required

In order for the lesson to be carried out, the appropriate setting must be available, preferably a classroom. Personal computers are a necessity along with all data inputting equipment and navigation equipment (mouse and keyboard). Internet service of course must be established. A projector and a projector screen were not a must-have but greatly improved the lesson.

Instructor's Assessment and Student Learning Outcomes

The instructor was able to actively assess each student based on their program's success. Not only was the instructor able to assess the students based on this standard but also on the quality of the program and its complexity. The complexity of the program was of importance but not complexity of the coding as efficiency and pragmatism in coding was encouraged. At the end of the program all of the students participated in a questionnaire where comprehensive questions were asked. All students demonstrated an adequate understanding.

Screenshots of Student Activities

Figures 1 and 2 are examples of the introduction activity, where students introduced themselves to the rest of the class. The students created a sprite that resembled themselves and then programmed the sprite to speak.

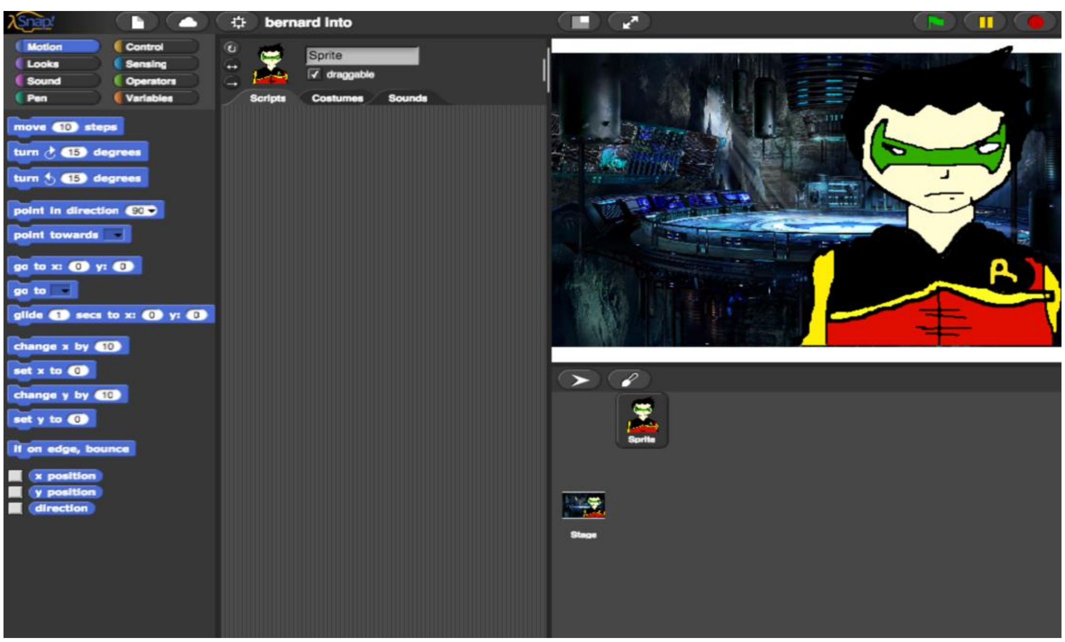

Figure 1. Screenshot of introductory student activities, example 1

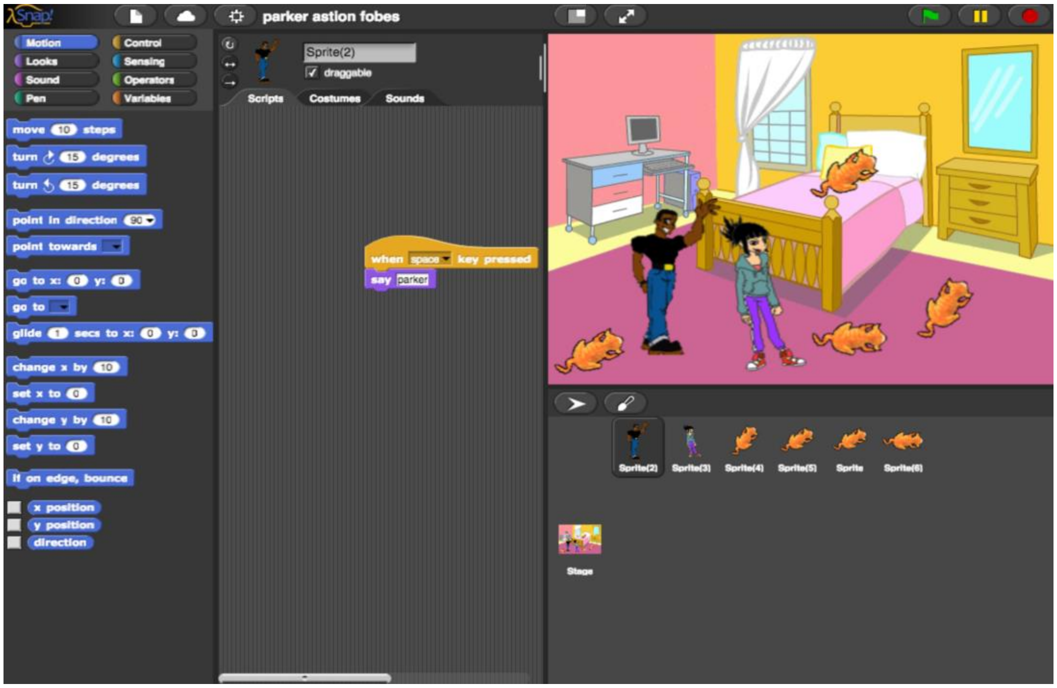

Figure 2. Screenshot of introductory student activities, example 2

Figures 3, 4, and 5 are the screenshots of the activities performed by the students when asked to create a sprite of their favorite animal or a fantasy creature.

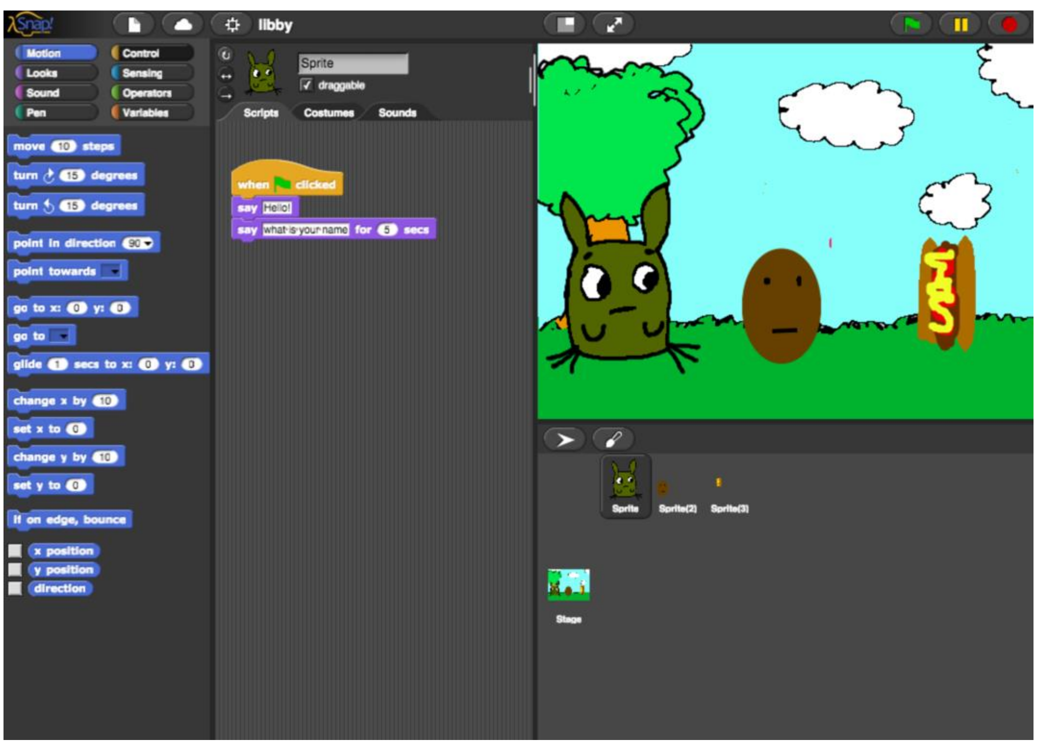

Figure 3. Screenshot of student activities when asked to create a sprite, example 1

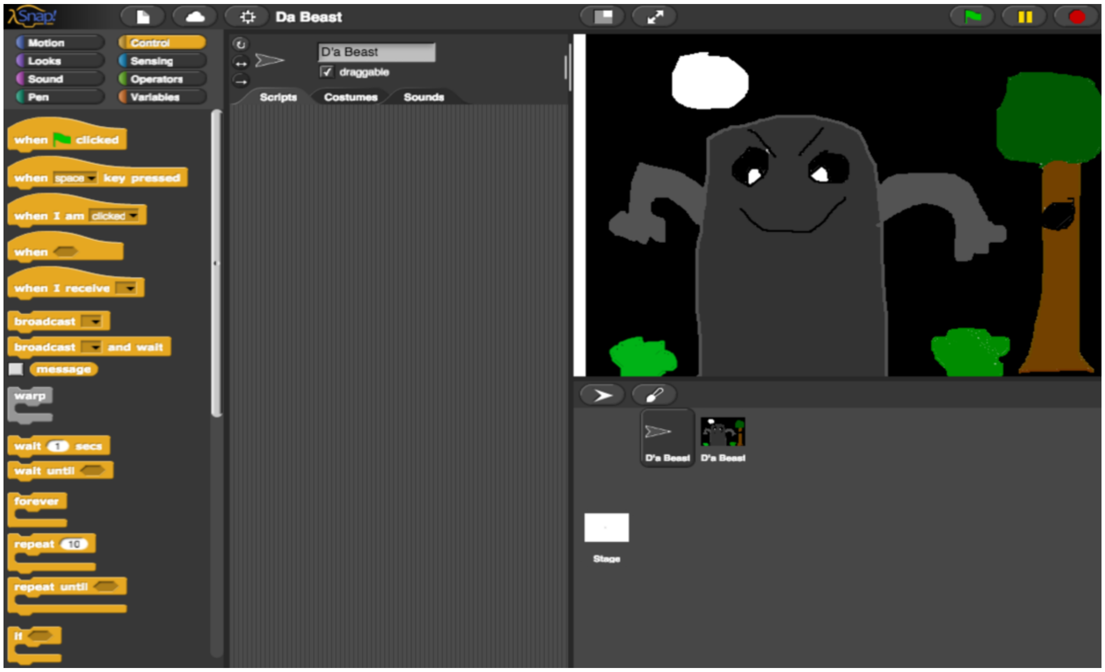

Figure 4. Screenshot of student activities when asked to create a sprite, example 2

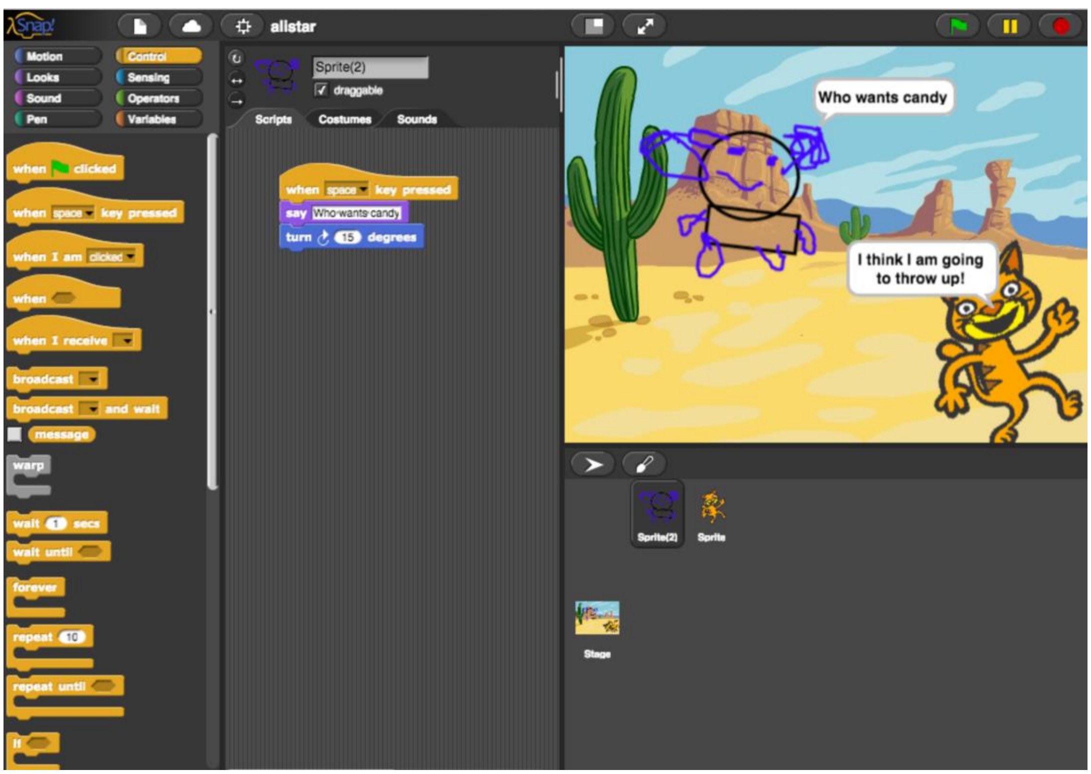

Figure 5. Screenshot of student activities when asked to create a sprite, example 3

Figures 6 and 7 are Snapshots of the animation activity where students created the illusion of movement with sprite costumes and loop commands.

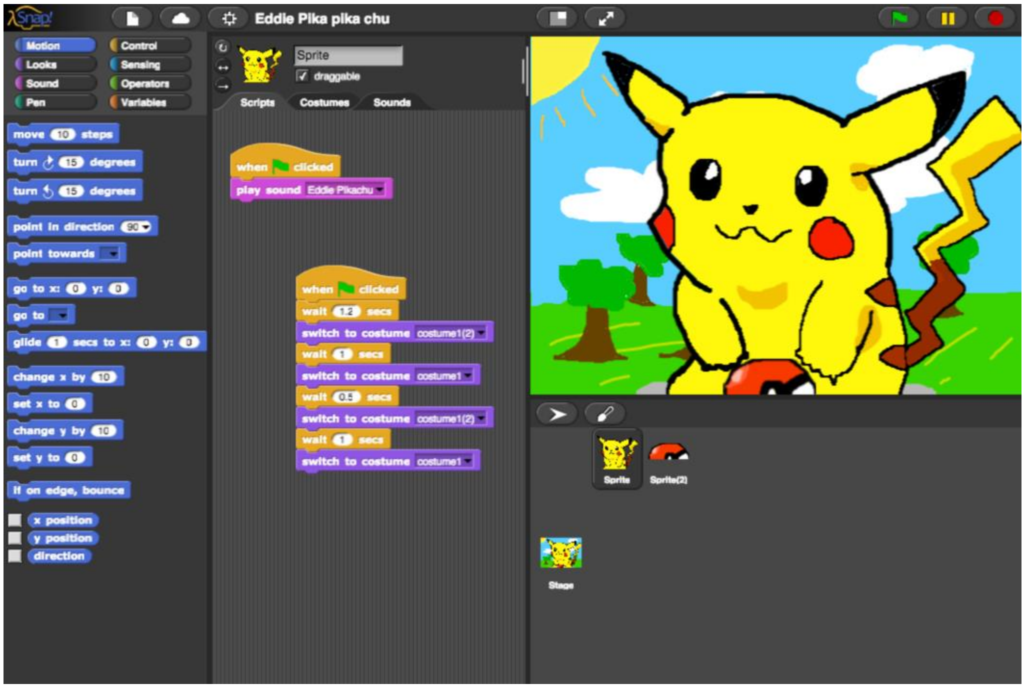

Figure 6. Screenshot of animated activities, example 1

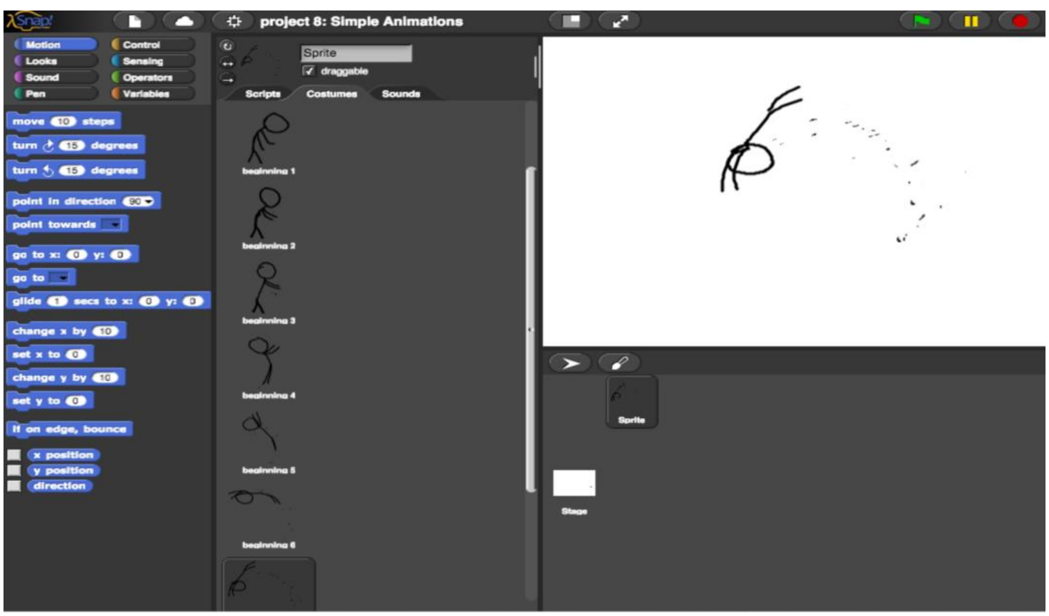

Figure 7. Screenshot of animated activities, example 2

The screenshot in Figure 8 is the faulty game created by the teachers. The students were to fix the program and make it so the game played well and fairly.

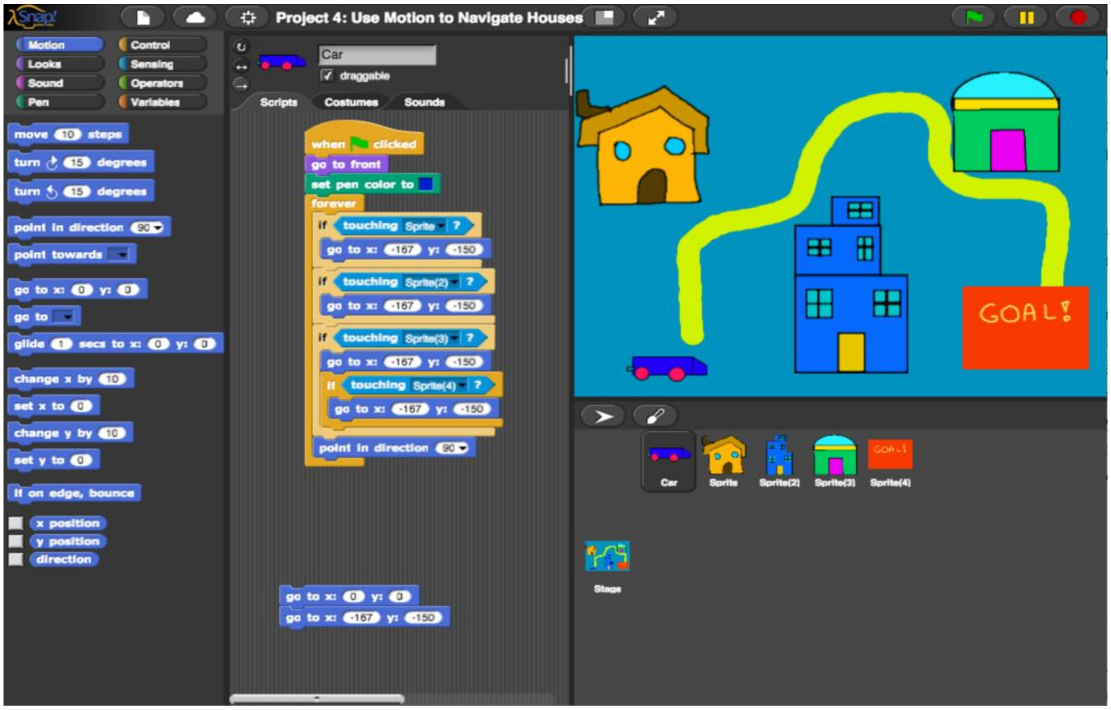

Figure 8. Screenshot of faulty game created by the teachers.

Assessment Method

In-class assessment of summer students was conducted by the participants. The survey questions were generated from literature reviews and teacher interviews and were reviewed by the Noyce team. Assessment results for Civil and Electronics Engineering Technologies and Mathematics are shown in Table 2. Results shows that the mean for all three areas were greater than 4.00.

Table 2: Assessment by Participants

Questions	Mean (out of 5.00)		
	Civil Eng. Tech (Population Size: 50)	Electronics Eng. Tech (Population Size: 76)	Math (Population Size: 51)
1. Teacher is well prepared for class.	4.74	4.75	4.82
2. Teacher is organized and neat.	4.52	4.63	4.53
3. Teacher is clear in giving directions and on explaining what is expected on assignments and tests.	4.68	4.61	4.67
4. Teacher allows you to be active in the classroom learning environment.	4.36	4.43	4.84
5. I have learned a lot from this teacher about this subject	4.58	4.50	4.65
6. Teacher listens and understands students.	4.38	4.45	4.71
7. Teacher respects the opinions and decisions of students.	4.54	4.55	4.86
8. Teacher is fun to be with.	4.56	4.50	4.84
9. Teacher likes and respects students.	4.58	4.63	4.90
10. Teacher helps you when you ask for help.	4.54	4.58	4.78
11. I trust this teacher.	4.44	4.50	4.78

Conclusion

In an effort to create interest in teaching, the student interns were engaged in course development and teaching in the areas of Math and Technology. Lesson plans were delivered by the students in real world classroom setting. Future plans are to assimilate the lesson plans and add the plans to the XXX University-Noyce website.

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