Introducing Engineering and Programming Concepts to Middle School and High School Students using SparkFun Inventor's Kit, Scratch, and Java

Callan J. Noak
Lamar University
Beaumont, TX USA
cnoak@lamar.edu

Sujing Wang
Lamar University
Beaumont, TX USA
sujing.wang@lamar.edu

Stefan Andrei
Lamar University
Beaumont, TX USA
sandrei@lamar.edu

Jennifer L. Tsan
Lamar University
Beaumont, TX USA
jtsan@lamar.edu

***Abstract*—This innovative Practice Full Paper establishes two one-week summer camps to introduce fundamental engineering and programming concepts to middle-school and high-school students using the SparkFun Inventor's Kit, Scratch, Makers Empire 3D Design Software, and Java. The SparkFun Inventor's Kit is a great way to introduce electronics and programming concepts to students who have little, no previous programming, or circuit construction experience. During the one-week summer camp, students were introduced to the Arduino-based SparkFun Inventor's Kit as the hardware platform, along with Arduino's Integrated Design Environment (IDE) for programming. Scratch was used to teach fundamental programming concepts such as arithmetic operations, strings, conditional statements, and loops. The motivation of our program is to offer hands-on engineering and programming experiences for middle-school and high-school students to increase their interests and knowledge in engineering and computing to promote student participation to meet the growing demand. Our program is unique in several ways: First, we developed several hands-on projects to integrate topics related to engineering and computing to help students develop and build skills of critical thinking, problem-solving, and invention. Second, we used several teaching tools, e.g., SparkFun Inventor's Kit, Scratch, Makers Empire 3D Design Software, and Java to enrich students' learning experience, while other programs used only one of those teaching tools. Third, we adopted several strategies to enrich our program, such as social encouragement, academic exposure, career perception, and social learning, which have shown beneficial effects on student learning in the literature to improve learning outcomes. Fourth, we also provided students the opportunity of a campus tour to help students get familiar with college life. Fifth, we organized team-building activities outside the classroom to build skills of effective collaboration and communication. Participants obtained a better understanding of principle programming, engineering concepts, and confidence in engineering and computing. The assessment results showed a significant increase in knowledge and interest in engineering and computing. This paper introduces the detailed information about our program organization, coordination, core curriculum design, and program assessment for organizing similar summer camps at other institutions and further prompts the effort to increase participation in engineering and computing fields.**

Keywords—engineering, computing skills, Scratch, SparkFun Inventor's Kit, Java, Makers Empire 3D Design Software, summer camp, engineering curriculum, assessment

I. INTRODUCTION

The U.S. Bureau of Labor Statistics reported that employment in computer and information technology occupations is projected to grow 13 percent from 2020 to 2030, faster than the average for all occupations, and employment in engineering is projected to grow 6 percent from 2020 to 2030 [1]. While the demands for the computing and engineering workforce remain strong, the supply remains weak. To meet the growing workforce needs in engineering and computing, we need to encourage more students to study and participate in those fields. It has been approved that introducing engineering and computing concepts to students at an early age can help encourage them to study and participate in the workforce in the future. However, computer science and engineering learning opportunities are limited in K-12 education, for example, 51% of American high schools offer foundational computer science but disparities in access persist [2]. Rural schools, urban schools, and schools with high percentages of economically disadvantaged students continue to be less likely to offer computer science and engineering [3]. Students need more opportunities at the K-12 level to learn engineering knowledge, computing knowledge, and skills that prepare them for college and careers.

Many initiatives have been launched to stimulate interest in engineering and computing disciplines nationally. Summer camps for K-12 students have become very popular to introduce engineering skills, scientific principles, and programming concepts to increase the students' knowledge and interests. In summer 2021, a group of faculty members from our institution and regional school districts collaborated and organized two one-week summer camps to introduce engineering and programming concepts to middle school and high school students. Our program was supported by the Texas Workforce Commission (TWC). The primary goal of our program is to introduce middle school and high school students to fundamental programming, engineering knowledge, and college life to increase the students' interests and experience leading to their selection of engineering and computing as a career choice and major in higher education. Sixty-five students from several financially disadvantaged school districts participated. We utilized the SparkFun Inventor's Kit, Scratch, Makers Empire 3D Design Software, and Java for fun hands-on activities to demonstrate engineering and programming concepts to middle school and high school students. Pre-and-post student surveys were administered to assess the success of our program.

Assessment results indicated our program had a positive impact on students' attitudes towards engineering and programming.

The rest of this paper is organized as follows. Section 2 introduces the related work in the literature and discusses how our program is unique compared to others. Section 3 describes how our program is organized. Section 4 discusses our core curriculums. It includes a brief description of the instructional materials and the concepts taught in each hands-on session. Section 5 explains how our program was assessed and the assessment results were analyzed. Conclusions and future works are in Section 6.

II. RELATED WORK AND CONTRIBUTIONS

Many institutions and organizations offer summer camps to introduce fundamental programming and engineering concepts to students at an early age. There are several popular educational kits and software used for those camps, such as LEGO robotic, Raspberry PI, SparkFun Invertor's Kit, Scratch, App Inventor, Python, Java, etc. Dr. Anjum and Mr. Wilcox organized a computing camp to teach 6th graders computing concepts at the Los Osos Middle School in California during the summer of 2019 [4]. Based on students' feedback, the camp was successful in inspiring the students and teaching them the skills needed to be successful in a STEM career. Miller et al. [5] held several week-long summer camps at the University of Southern California to teach K-12 students about computer science. Lee et al. [6] also organized summer camps for middle school and high school students. They used MIT's App Inventor to teach basic coding concepts. In [7], a summer camp was held for high school students in 2013 to teach students computer science topics using interactive musical robots. Based on feedback from the campers, the camp was successful in increasing interest in Computer Science and other STEM-related fields. Nite et al. [8] held a summer camp for 7th to 12th graders focused on microcontrollers to increase interest in STEM-related fields and to teach them the skills necessary to succeed in those fields. In [9], a Computer Science summer camp was held for incoming college freshmen to better prepare them to be successful in their academic careers. The camp covered technical topics that the students will come across in their studies as well as college readiness topics such as a resume workshop. The camp was able to cover all the planned topics and even saw two students change their majors to Computer Science.

Introducing computing and engineering concepts to students, particularly women and minorities at an early age can help encourage them to study computing and engineering. Many institutions and organizations organized summer camps to increase interest in Computer Science for girls. In [10], a Females in Technology Summer Boot Camp was held for high school senior girls to increase the number of female students who might pursue degrees in technology. Based on the pre-and-post student surveys, the camp was able to increase the participants' knowledge, interest, and attitude toward technology. In [11], a summer camp was held for female high school students to encourage them to attend college and pursue a major in STEM. AlHumoud et al. [12] held a two-week summer camp for high school girls to teach them about Computer Science topics using App Inventor and LEGO Mindstorm NXT. They found that the campers best learned with hands-on training activities and minimal lecturing. In [13], a summer camp for middle school girls was held to introduce female students to the fields of STEM in San Antonio, Texas. The camp introduced a variety of Computer Science topics such as robotics, MATLAB, programming, and game design. In [14], a summer camp for high school girls was held in Saudi Arabia to introduce Computer Science concepts to attract potential students who might choose Computer Science as their college major. The camp covered different topics from basic programming concepts to game design.

We designed and implemented two one-week summer camps that utilized the SparkFun Inventor's Kit, Scratch, Makers Empire 3D Design Software, and Java to offer students hands-on programming and engineering experiences to increase their knowledge and interests in computing and engineering. Our program is unique in several ways: First, we focused on hands-on projects to integrate topics related to electronic engineering and computing to help students develop and build skills of critical thinking, problem-solving, and invention. Second, we utilized several teaching tools, e.g., Spark Fun Inventor Kit, Scratch, Makers Empire 3D Design Software, and Java, while others focused on one of those teaching tools only. Third, we adopted several strategies to enrich our program, such as social encouragement, academic exposure, career perception, and social learning, which have shown beneficial effects on student learning in the literature to improve learning outcomes. For example, we adopted pair programming and buddy system for our camps. Campers were assigned a buddy at the beginning of the camp and were expected to remain with their buddy at all times during the duration of the camp. Campers collaborated with their buddy as a pair completing all projects. For career awareness, we hosted a parent and student orientation before the camp to inform parents and students about a wide variety of engineering careers available for campers. Fourth, we also provided students the opportunity of a campus tour to help students get familiar with college life. Fifth, we organized team-building activities outside the classroom to build skills of effective collaboration and communication. Participants obtained a better understanding of principle programming, engineering concepts, and confidence in engineering and computing. Assessment results showed an increased interest and self-reported understanding of engineering and computing topics after participants completed the camp as well as high self-efficacy throughout the camp experience. Our program and the hands-on interactive activities can be transferred to other locations or universities with varying resources available.

III. PROGRAM ORGANIZATION

Organizing summer camps are important tasks including core curriculum design, camp brochure design and distribution, call for applications, application review and selection, computing lab and classroom reservation, software installation, dining hall reservation, parent and student orientation, ordering of camp T-shirts, instructors and staff training, etc. We collaborated with several regional school districts to recruit students. We met with school counselors to discuss the application process to recruit students from historically underserved populations. The Court-Appointed Special Advocates (CASA) organization assisted in identifying low-income students in foster care. Applications were accepted for

consideration regardless of status, i.e., students with disabilities, youth in foster care, students from low-income families, and ethnic and racial status. For the first camp, there were 35 students. The first camp participant diversity is listed in Table I. The first camp enrollment by ethnicity is shown in Figure 1. For the second camp, there were 30 students. The second camp participant of diversity is listed in Table II. The second camp enrollment by ethnicity is shown in Figure 2. There were more than 50% of female participants in both camps. The majority of our camp participants in both camps were minority students.

TABLE I. THE FIRST CAMP PARTICIPANT DIVERSITY

Ethnicity	Female	Male
American Indian or Alaska Native	0	0
Asian	1	2
Black or African American	5	8
Hispanic, Latino, or Spanish	9	5
Native Hawaiian or Pacific Islander	0	0
Other	3	2
Total	18	17

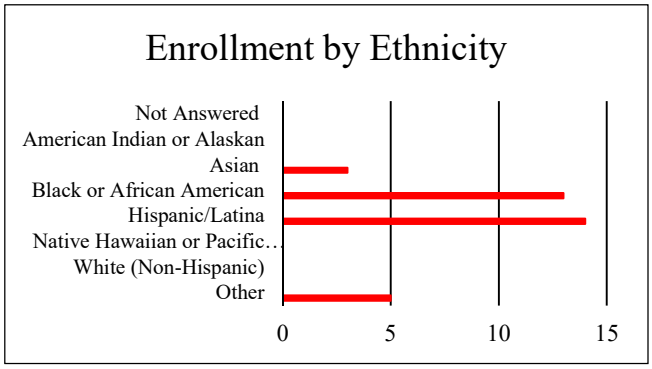

Fig. 1. The First Camp Enrollment by Ethnicity

The detailed camp schedule is listed in Table III. Students started to check in around 8:45 am to 9:00 am each day. From 9:00 am to noon, students worked on the SparkFun Inventor's Kit projects. From noon to 1:00 pm, students ate lunch at the campus's dining hall. From 1:00 pm to 4:00 pm, students worked on Mission to Mars, Scratch, and Java projects. Students started to check out at 4:00 pm each day. To create a good classroom environment by getting students to work together in groups and respect each other, we also organized team-building activities at the campus's recreation center. On the last day of camp, students presented their projects and inventions to a panel of judges and peers and attended the award ceremony.

TABLE II. THE SECOND CAMP PARTICIPANT DIVERSITY

Ethnicity	Female	Male
American Indian or Alaska Native	0	0
Asian	5	2
Black or African American	7	5
Hispanic, Latino, or Spanish	3	6
Native Hawaiian or Pacific Islander	0	0
Other	1	1
Total	16	14

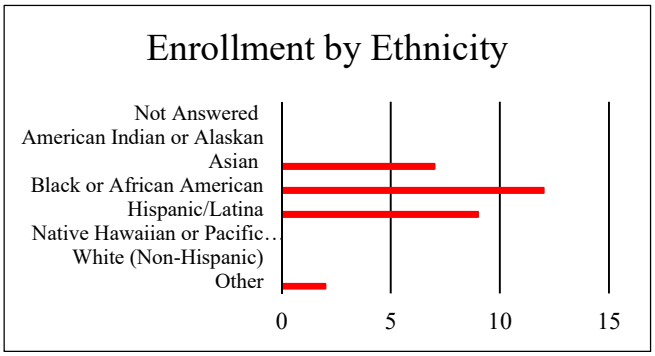

Fig. 2. The Second Camp Enrollment by Ethnicity

TABLE III. CAMP SCHEDULE

Monday	
8:50 AM	Check-In
9:00 AM – 12:00 PM	SparkFun
12:00 PM – 1:00 PM	Lunch
1:00 PM – 4:00 PM	Maker Space Scratch Software
4:00 PM	Student Dismissal
Tuesday	
8:50 AM	Check-In
9:00 AM – 12:00 PM	SparkFun
12:00 PM – 1:00 PM	Lunch
1:00 PM – 4:00 PM	Maker Space Scratch Software
4:00 PM	Student Dismissal
Wednesday	
8:50 AM	Check-In
9:00 AM – 11:00 PM	SparkFun
11:00 AM – 12:00 PM	Team Building Activity
12:00 PM – 1:00 PM	Lunch
1:00 PM – 4:00 PM	Java Programming
4:00 PM	Student Dismissal
Thursday	
8:50 AM	Check-In
9:00 AM – 11:00 AM	SparkFun
11:00 AM – 12:00 PM	Campus Tour
12:00 PM – 1:00 PM	Lunch
1:00 PM – 4:00 PM	Java Programming
4:00 PM	Student Dismissal
Friday	
8:50 AM	Check-In
9:00 AM – 12:00 PM	SparkFun
12:00 PM – 1:00 PM	Lunch
1:00 PM – 4:00 PM	Student Presentation Pre/Post Evaluations Award Ceremony
4:00 PM	Student Dismissal

IV. Core Curriculum Instruction

The study of electronic engineering and computing includes the principles, hardware and software designs, and implementation. Learning engineering and computing fosters curiosity and imagination [2]. It provides opportunities to think critically, solve problems, take risks, make mistakes, learn from them, and help others to do the same [2].

We have accomplished the following activities which benefitted our camp participants:

- SparkFun Inventor's Kit Projects
- Java Programming Projects
- The Mission to Mars Design Challenge Project
- Scratch Programming Project
- Maker Empire 3D Design Project
- Team Building Activities
- Campus Tour
- Student Presentation

We utilized the SparkFun Inventor's Kits to teach students programming and engineering design techniques. The SparkFun Inventor's Kit is a creative hands-on learning tool for students to develop fundamental skills to explore the world of electronics and programming. SparkFun products provide a powerful and in-depth engineering design experience and programming experience for our students.

The Mission to Mars Design Challenge Activity utilized Makers Empire 3D Design Software and Scratch software. This activity allowed students to explore and determine the specific needs of a mission to Mars while challenging them to brainstorm, design, and create an invention or tool. This activity encouraged students to practice and hone not only design and technological skills but also team cooperation and presentation skills.

Scratch is a programming language developed to help students between the ages of 8 and 16 to learn skills by developing computer programs. By using code blocks in place of complex program text statements, Scratch significantly simplifies application development while still making use of the same basic programming logic and concepts implemented in other programming languages. Students can only snap-together blocks in ways that make syntactic sense, thus eliminating syntax errors that proliferate in other programming languages. Despite its use of graphical code blocks, Scratch supports the same basic set of programming techniques and constructs as other traditional programming languages.

We also introduce Java programming. Java is one of the long-standing high-level programming languages in the world. We hope to hone students' Java skills with console application and programming challenges.

We also organized several team-building activities and a campus tour for our camp participants. For example, we taught students graphic design for Mission to Mars project and have students craft something creative. We hold a competition to see which group of designers was the best. The judges evaluated the design and awarded the winner with First Place certificate. We called this Designer Competition team-building activities.

A. Curriculum Content for the SparkFun Inventor's Kit

The SparkFun Inventor's Kits provide students the opportunity to learn from hands-on experiences. Having two students as one group working on each SparkFun Inventor's Kit was very successful. Pair programming is one of our best practices. Table IV lists all hands-on SparkFun projects that we taught for both camps.

TABLE IV. SparkFun Projects

Setup the SparkFun Inventor Kits
Circuit 1A: Blinking an LED
Circuit 1A: Changing Code
Circuit 1B: Potentiometer
Circuit 1B: Changing Code
Circuit 1C: Reading a Photoresistor
Circuit 1C: Changing Code
Circuit 1D: RGB Night-Light
Circuit 1D: Changing Code
Circuit 2A: Buzzer
Circuit 2A: Changing Code
Circuit 2B: Digital Trumpet
Circuit 2B: Changing Code
Circuit 2C: "Simon Says" Game
Circuit 2C: Changing Code
Circuit 3A: Servo Motor
Circuit 3A: Changing Code
Circuit 3B: Distance Sensor
Circuit 3B: Changing Code
Circuit 3C: Motion Alarm
Circuit 3C: Changing Code
Circuit 4A: LCD "Hello, World!"
Circuit 4A: Changing Code
Circuit 4B: Temperature Sensor
Circuit 4B: Changing Code
Circuit 4C: DIY "Who am I?" Game
Circuit 4C: Changing Code
Circuit 5A: Motor Basics
Circuit 5A: Changing Code
Circuit 5B: Remote-Controlled Robot
Circuit 5B: Changing Code
Circuit 5C: Autonomous Robot
Circuit 5C: Changing Code
Final Project

Figure 3 shows the completed SparkFun board by our students for Circuit 2C: "Simon Says" Game project. The program controlled LEDs to flash a pattern, which the plays must remember and repeat using four buttons. This simple electronic game has been a classic since late 1970. Figure 4 shows a screenshot of the program used for this project. The students needed to follow the circuit diagram and hookup table to connect all the hardware successfully, i.e., four LEDs, one potentiometer, one piezo buzzer, 16 jumper wires, and four push buttons on the breadboard. We taught the students the concepts of if-else statements, loops, and arrays in this project.

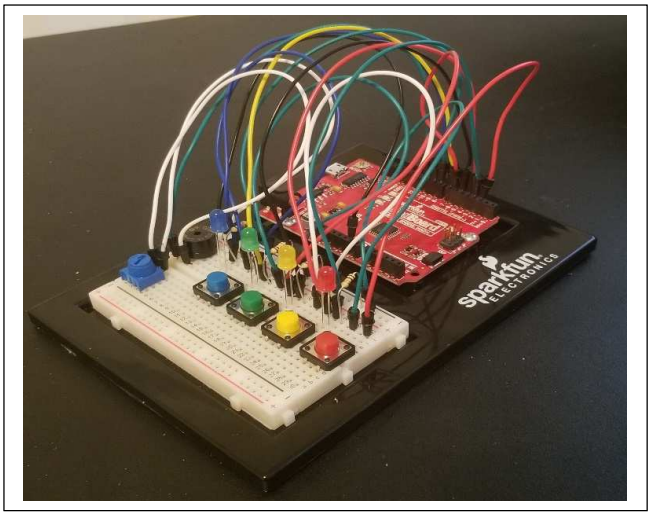

Fig. 3. SparkFun Board for Circuit 2C: Simon Says Game

```
//CHECK WHICH BUTTON IS PRESSED
int buttonCheck() {
  //check if any buttons are being pressed
  if (digitalRead(button[0]) == LOW) {
    return 0;
  } else if (digitalRead(button[1]) == LOW) {
    return 1;
  } else if (digitalRead(button[2]) == LOW) {
    return 2;
  } else if (digitalRead(button[3]) == LOW) {
    return 3;
  } else {
    return 4; //this will be the value for no button being pressed
  }
}

//START SEQUENCE
void startSequence() {

  randomSeed(analogRead(A0));   //make sure the random numbers are really random

  //populate the buttonSequence array with random numbers from 0 to 3
  for (int i = 0; i <= roundsToWin; i++) {
    buttonSequence[i] = round(random(0, 4));
  }

  //flash all of the LEDs when the game starts
  for (int i = 0; i <= 3; i++) {

    tone(buzzerPin, tones[i], 200); //play one of the 4 tones

    //turn all of the leds on
    digitalWrite(led[0], HIGH);
    digitalWrite(led[1], HIGH);
    digitalWrite(led[2], HIGH);
    digitalWrite(led[3], HIGH);

    delay(100);         //wait for a moment

    //turn all of the leds off
    digitalWrite(led[0], LOW);
    digitalWrite(led[1], LOW);
    digitalWrite(led[2], LOW);
    digitalWrite(led[3], LOW);

    delay(100);   //wait for a moment

  } //this will repeat 4 times
}
```

Fig. 4. Code Snippet from Circuit 2C: Simon Says Game

B. *Curriculum Content for Mission to March project*

The Mission to Mars activity aimed to provide a best practice model for technology integration into a STEM classroom activity. The activity allowed students to authentically interact and utilize instructional technology tools to complete a synthesis-based task. This activity demonstrated how STEM activities can be structured so that students lead their learning and success while instructors serve as facilitators and helpers. Table V shows the Mission to Mars curriculum plan, student learning objectives, and the skills related to each core curriculum subject. In addition to creating a 3D-designed prototype of their invention, students had to present their invention to a panel of judges and peers with the intent to sell their design.

TABLE V. MISSION TO MARS CURRICULUM PLAN

Core Curriculum Subjects	21st Century Skills	Learning Objectives
Physics Engineering Mathematics Technology Communication	Reflection Communication Critical Thinking Research	Students will learn about SpaceX's successful Falcon Heavy rocket launch as well as current challenges facing its team, as they seek to become the first manned mission to Mars.
Physics Engineering Mathematics Technology Communication	Reflection Communication Critical Thinking Group Participation Research Problem Solving	Students will have the chance to invent and create their invention, tool, or other product to be used during the mission to Mars.
Mathematics Technology Communication	Critical Thinking Problem Solving	Students will learn foundational skills in the Scratch programming language.
Engineering Mathematics Technology Communication	Critical Thinking Problem Solving	Students will learn foundational skills in using the Makers Empire Create Tools (Shaper and Blocker).
Communication	Reflection Communication Group Participation Presentation	Students will use presentation skills to develop and present a group presentation of their Mars Invention.

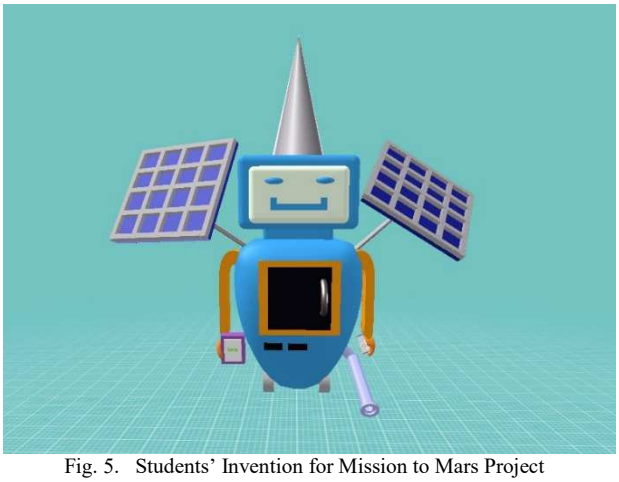

Fig. 5. Students' Invention for Mission to Mars Project

Makers Empire 3D Design can help students learn to collaborate, think critically about complex problems, design creative solutions to the challenges presented, and share their knowledge with the other community of learners. Using Makers Empire 3D Design software gave the student the ability to manifest their understanding visually in virtual form. Figure 5 shows one student's invention for the Mission to Mars project.

C. Curriculum Content for Scratch

Scratch is a free coding language online community that engages millions of children in creating and sharing interactive stories, animations, and games. We covered the basic concepts of Scratch, including variables, conditional and iterative logic, event-driven programming, manipulation of graphics, and the integration of sound into application projects. Figure 6 displays the snippet of the Scratch code that our students implemented. The project we selected for both camps was to design a project related to 'Mission to Mars'. This project was connected to the same project in the summer camps but from the perspective of building a space station on Mars. Our students were exposed to a program called "Safe landing on Mars", which was a Scratch program to simulate a safe landing, including simulating the animation for opening the parachute, reducing speed, and lowering the main module with the land rover on the surface of Mars.

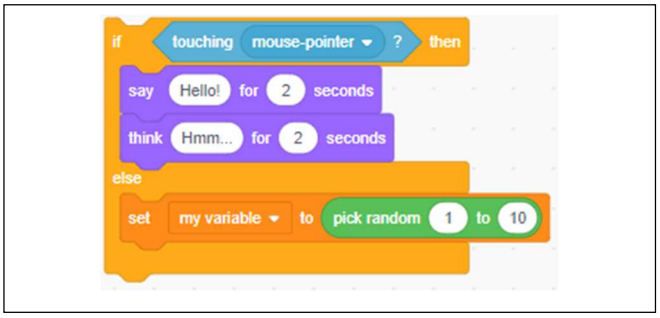

Fig. 6. Scratch Programming Snippet

D. Curriculum Content for Java

Java is one of the most popular programming languages in the world. After students completed Maker Empire and Scratch Projects, we then taught them Java programming. The topic we covered included:

- Console output
- Variables
- Data types
- Console input
- If-else statement

By the end of the camps, students improved their skills in Java and gained a better understanding of high-level programming languages. Additionally, students gained a head start in the AP Computer Science class.

V. Program Assessment

A pre-post evaluation survey was utilized towards participants' pre-post knowledge and interests acquired for all objectives. The pre-post evaluation survey consisted of a Likert five-point scale of knowledge acquired where "1" is the lowest score and "5" is the highest score. Table VI lists the pre/post survey questionnaires.

The average rating for each intervention method was based on the net gain value: where 1.00-1.24 Meets Standard, 1.25-1.49 are good; 1.50-1.74 are Excellent, and 1.75 and above are Outstanding. The formula for net gain value is the difference between the post knowledge and interest score and the pre-knowledge and interest score. Table VII displays the assessment result. Survey results reflected that intervention activities such as Educational Presentations, Hands-on Activities, Student Research Teams, and Student Engineering and Computing Career Interest rated outstanding. There was also the opportunity for students to make comments related to the overall camp activities and experiences, which resulted in all positive comments. Table VIII shows the open questions' responses.

TABLE VI. Pre/post Survey Questionnaires

Statement		Response				
		Low		*Average*		*High*
Knowledge of Makers Empire	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of 3D Model Design	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of Presentation Skills	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of Designing the SparkFun Inventor's Kit	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of Programming with SparkFun Inventor's Kit	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of Scratch Programming	Before	1	2	3	4	5
	After	1	2	3	4	5
Knowledge of Java Programming	Before	1	2	3	4	5
	After	1	2	3	4	5
Interest in Computing	Before	1	2	3	4	5
	After	1	2	3	4	5
Confidence Level of Your Ability to Succeed in Computing	Before	1	2	3	4	5
	After	1	2	3	4	5
Interest in Engineering	Before	1	2	3	4	5
	After	1	2	3	4	5
Confidence Level of Your Ability to	Before	1	2	3	4	5

Succeed in Engineering	After	1	2	3	4	5
Interest in Preparing for a Computing or Engineering Career	Before	1	2	3	4	5
	After	1	2	3	4	5
Would you recommend this camp to a friend?				Yes		No
What suggestions do you have for improving the camp?						
What did you like most about the camp?						
Please comment about your experience of learning new /programming/Engineering skills.						
Please write any other comments you may have.						

TABLE VII. PROGRAM ASSESSMENT RESULTS

Question	Gain
Knowledge of Makers Empire	2.89
Knowledge of 3D Model Design	1.71
Knowledge of Presentation Skills	1.06
Knowledge of Designing with SparkFun Kit	2.74
Knowledge of Programming with SparkFun Kit	2.31
Knowledge of Scratch Programming	1.77
Knowledge of Java Programming	1.59
Interest in Computing	1.14
Confidence In Your Ability to Succeed in Computing	1.29
Interest in Engineering	1.49
Confidence in Your Ability to Succeed in Engineering	1.17
Interest in Preparing for a Computing or Engineering Career	1.26

The lowest gain was in three categories: “Knowledge of Presentation Skills”, “Interest in Computing”, and “Confidence in Your Ability to Succeed in Engineering”. Despite that, the gain was higher than 1.00, hence it met the standard. All the other questions obtained a “good”, “excellent”, or “outstanding” gain.

TABLE VIII. OPEN QUESTIONS’ RESPONSES

What suggestions do you have for improving the camp?
I have no suggestions the camp is perfect.
Nothing it's fine the way it is
A little bit more effort in time management
More time in the camp!
maybe have more than two classes each day
Nothing the camp is perfect the way it is
i think you guys did a nice job
Honestly, I think they did an amazing job with the camp, and the program itself.
Present the spark fun robots to the rest to the campers
There are no suggestions for improving this camp. It's great.
What did you like most about the camp?
Inventing a mars object and learning about SparkFun
I liked the SparkFun because it gave me an opportunity to experiment with code.
I liked learning how to code.
food and programing
the makers empire
Learning New stuff and being able to make my own invention
Coding with my friends.
the Counselors
Being able to do the spark fun projects.
I liked working with the inventor's kit and Makers Empire as a group
Makers Empire
The Spark fun kit
I enjoyed meeting new people and getting to connect with them via the groups.
the SparkFun kit
If you need help, they have no problem helping you and its fun
Meeting new people.
I got to meet new people.
Everything.
Working with the coding projects.
the spark fun inventors kit and the food at lunch
It has a great staff and nice environment.
The lunch and the Classes
Lunch and making some new friends
The SparkFun kit.
What I liked most about camp was the building things with the inventor's kit.
Being able to get hand's on with the activity that they had prepared for us.
I liked the programming the wires into the inventors kit the most.
the second part of the day where we played around with the spark fun kit. I liked messing around with the code, just to see what happened.
The most I liked about this camp is that I liked how detail and helpful they can be whenever a student needs help even if they don't.
Please comment about your experience of learning new programming/engineering skills.
My experience was good because I learned more about the Arduino coding language.
it was interesting and cool
They taught it very well and broke it down so I could understand.
I learned how to make a cartoon move.
I learned how to create a Scratch program and how to use in more.
it was very eye-opening
It was great to learn about some people that are going to the same school as me
I love it, at the beginning I thought I was not going to like it but I will be back next year for sure
I learned many new things about coding, programming, and computer science skills.

I learned that I am not a big fan of computer science but I have learned a lot, I just don't know how to put it in words.
it was fun and entertaining
My experience about coding/programming and computer science skills are average.
I guess learning those types of skills will come in handy and kind of fun.
the overall experience was fun learning something new that I never learned before
I learned tons of new things that I never even thought about.
The experience was great I would come back next year if I have a chance
At first, I was confused and struggling and now, I'm still confused and struggling but I getting better
Before attending this camp, I honestly had no idea how to do coding, or any sorts or computer science, but after attending, I now know how to do all sorts of things, hopefully I'll get to use them in the future, but I doubt it, since this has nothing to do with my career path.
It was really interesting, and fun learning about coding, programming, and computer science skills that I didn't know before.
I enjoyed being able to program on scratch and get hands with the robot. being able to make it move without touching the mouse or the keyboard was really cool
I learned in this past week, but what took my interest the most was the coding/programming class.

Based on the assessment results, we also observed that learning high a level programming language such as JAVA without any previous programming experience is challenging for middle school and high school students. However, hands-on projects utilizing SparkFun Inventor Kits are highly engaging. We conclude that our summer camps were effective in meeting the standards and beyond.

Based on our experience as the designers of the camp, there are areas that need improving. Based on participants' feedback, instructional methods and basic structure will remain the same for future academies with robotics and programming as the content. However, the participants commented that the camps were too short. The possibility of extending the camps to two weeks or longer to introduce more content will be explored for future summer camps.

VI. Conclusion and Future Works

Based on the feedback and assessment results from participants, our program succeeded in its goal to open doors for middle school and high school students in the world of engineering and computing. We plan to organize similar summer camps in the future. Our program can be transferred to other institutions with varying resources available. Here are the suggestions for those who plan to scale such programs at their institutions. There are several educational robotics available on the market, such as LEGO Robotics and Raspberry Pi. You can choose the one that fit your budget. You can also add other content to enrich your program, such as 3D printing and Cybersecurity. Learning a high-level programming language is very changeling for middle school students without any programming experience. Starting with Scratch, then transits to Java, could help.

Acknowledgment

This project was supported by the Texas Workforce Commission (TWC).

References

[1] Bureua of Lab Statistics, "occupational outlook handbook", https://www.bls.gov/ooh/computer-and-information-technology/home.htm, last visit, Mar. 2022. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] 2021 State of Computer Science Education. (2021). Retrieved from https:// advocacy.code.org

[3] An Engineering Summer Program for Underrepresented Students from Rural School Districts, Matthew E. Elam, Brent L. Donham, Stephanie R. Solomon, Journal of STEM Education, Volume 13, Issue 2, April 2012

[4] B. Anjum and G. Wilcox, "Computer Science is about Problem Solving: Highlights from a 6th Grade Computing Camp," 2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT), 2020, pp. 1-4, doi: 10.1109/RESPECT49803.2020.9272426.

[5] J. Miller, S. Raghavachary and A. Goodney, "Benefits of Exposing K-12 Students to Computer Science through Summer Camp Programs," 2018 IEEE Frontiers in Education Conference (FIE), 2018, pp. 1-5, doi: 10.1109/FIE.2018.8659101.

[6] J. Lee, S. Jun, K. Kim and I. Yoon, "Summer Programming Boot Camp, Teach High Schoolers First and Let Them Teach Middle Schoolers," 2016 International Conference on Computational Science and Computational Intelligence (CSCI), 2016, pp. 287-292, doi: 10.1109/CSCI.2016.0062.

[7] C. J. C. J. Chung, C. Cartwright and C. Chung, "Robot music camp 2013: An experiment to promote STEM and computer science," 2014 IEEE Integrated STEM Education Conference, 2014, pp. 1-7, doi: 10.1109/ISECon.2014.6891012.

[8] S. B. Nite, A. Bicer, K. C. Currens and R. Tejani, "Increasing STEM Interest through Coding with Microcontrollers," 2020 IEEE Frontiers in Education Conference (FIE), 2020, pp. 1-7, doi: 10.1109/FIE44824.2020.9274273.

[9] J. Raigoza, "An Experience Report on Running a Pre-College Computer Science Summer Program," 2018 International Conference on Computational Science and Computational Intelligence (CSCI), 2018, pp. 655-658, doi: 10.1109/CSCI46756.2018.00131.

[10] E. Sowells, L. Waller, A. Ofori-Boadu and G. Bullock, "Using technology summer camp to stimulate the interest of female high school students in technology careers," 2016 Portland International Conference on Management of Engineering and Technology (PICMET), 2016, pp. 1688-1696, doi: 10.1109/PICMET.2016.7806601.

[11] G. C. Gannod, J. E. Burge, V. McIe, M. Doyle and K. C. Davis, "Increasing awareness of computer science in high school girls," 2014 IEEE Frontiers in Education Conference (FIE) Proceedings, 2014, pp. 1-8, doi: 10.1109/FIE.2014.7044456.

[12] S. AlHumoud, H. S. Al-Khalifa, M. Al-Razgan and A. Alfaries, "Using App Inventor and LEGO mindstorm NXT in a summer camp to attract high school girls to computing fields," 2014 IEEE Global Engineering Education Conference (EDUCON), 2014, pp. 173-177, doi: 10.1109/EDUCON.2014.6826086.

[13] C. Wang and M. Frye, "miniGEMS 2018 Summer Camp Evaluation: Empowering Middle School Girls in STEAM," 2019 IEEE Integrated STEM Education Conference (ISEC), 2019, pp. 149-155, doi: 10.1109/ISECon.2019.8881981.

[14] M. Al-Duwis, H. S. Al-Khalifa, M. S. Al-Razgan, N. Al-Rajebah and A. Al-Subaihin, "Increasing high school girls awareness of computer science through summer camp," 2013 IEEE Global Engineering Education Conference (EDUCON), 2013, pp. 231-237, doi: 10.1109/EduCon.2013.6530111.

[15] S. Kamberi, "Exposing girls to computer science: Does the all-girl model really work?," 2017 IEEE Integrated STEM Education Conference (ISEC), 2017, pp. 152-155, doi: 10.1109/ISECon.2017.7910232.