Integrating Programming and Engineering Concepts using Raspberry Pi and Scratch

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***Abstract*—This Innovative Practice Full Paper introduces the design, organization, and assessment of a one-week summer camp geared towards integrating programming and engineering concepts using Raspberry Pi and Scratch for incoming 8th-grade female students to increase their interest and knowledge of Computing and Engineering. The purpose of offering this camp is to increase female participation in the computing and engineering fields to close the gender gap. This summer camp focused its efforts on teaching incoming 8th-grade female students the fundamentals of programming skills and engineering concepts. We taught our camp participants to use Raspberry Pi to build systems that explore fundamental programming and engineering concepts and develop engineering skills. Raspberry Pi provides a general programming environment with numerous interfaces to allow direct control of the hardware. This paper describes the organization, coordination, and core curriculum instructions that integrate programming and engineering concepts taught in each hands-on session and discusses the program assessment results. Our program assessment results showed that all camp participant cohorts increased their knowledge and interests in computing and engineering. This paper intends to provide all the information needed to host similar summer camps at other institutions, and further prompt the effort to increase female participation in computing and engineering fields.**

Keywords—*Raspberry Pi, Scratch, summer camp, gender, diversity, broadening participation, programming, engineering.*

I. Introduction

The employment of Science, Technology, Engineering, and Math (STEM) occupations is projected to increase by 8% from the year 2019 to 2029, according to the U.S. Bureau of Labor Statistics [1]. Engineering and computing are the most lucrative STEM fields. However, both fields remain heavily male-dominated. It is necessary to increase the participation of women's participation in both computing and engineering to meet the growing demand for computing and engineering occupations, and to increase diversity and gender equity. There are certain computing disciplines where the lack of female engineers/scientists is more severe such as cybersecurity, e.g., women will account for 25 percent of the cybersecurity workforce by the end of the year 2021 [23]. Offering summer camps and workshops to attract students, especially female students, at an early age to computing and engineering has become very popular. Many universities and organizations have developed different types of summer camps, academies, and workshops for young students. A team of faculty members from the department of computer science and the department of education at our institution conducted a one-week summer camp for incoming 8th-grade females with a grant awarded from Texas Workforce Commission (TWC). We focused on incoming 8th-grade female students because of the cognitive and social development associated with this age group, the freedom to modify their class schedule with electives, and the creation of social groups based on academics and after-school activities.

This summer camp design is to inspire and increase the participation of females in computing and engineering. We used Raspberry Pi and Scratch to demonstrate and integrate fundamental programming and engineering concepts through fun hands-on applications to increase female students' interests and knowledge in computing and engineering. The Raspberry Pi is an excellent platform for educational applications. Various courses for projects, such as computer science, electrical engineering, embedded systems, and control engineering, have used Raspberry Pi. The Lifelong Kindergarten Group created Scratch at the MIT Media Lab in Boston, Massachusetts, to help young people learn mathematical and computational concepts while having fun making applications. We use free software, e.g. Scratch so that if students enjoy what they have learned at our camp, they can continue learning at home. Moreover, students enjoyed creating 2D animations, interact art, music, and games using drag-and-drop programming such as Scratch.

Our summer camp is unique in several ways: first, we developed several hands-on projects based on Raspberry Pi and Scratch to integrate topics related to programming, electronic engineering, and control engineering. Second, we used both Raspberry Pi and Scratch as teaching tools for our camp, while other camps use either Raspberry Pi or Scratch, but not both. Third, the camp participants were incoming 8th-grade female students only, creating a non-competitive learning opportunity to improve their learning performance. This non-competitive learning opportunity is because there are no male students. Fourth, we adopted several strategies to enrich the summer camp, 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.

This paper describes the organization, coordination, content, and assessment of this summer camp. The paper's purpose is to share experiences and lessons learned from the 2018 summer camp to benefit those institutions considering adopting this practice. Contributions of this article include:

- Discussion of the literature review that indicates this type of summer camp can be effective in attracting females to computing and engineering;
- Description of how to organize and conduct the summer camp;
- Discussion of the Raspberry Pi instructional materials;
- Description of Scratch instructional materials;
- A detailed description of the assessment instruments and our results.

The remainder of this paper is organized as follows: section II introduces related works and the motivation of the summer camp, section III describes how the camp is organized, and section IV includes a brief description of the instructional materials and the concepts taught in each hands-on session. Section V discusses how the summer camp is assessed and the assessment results, while section VI discusses the first-year experience of conducting the camp and lessons learned. Lastly, conclusions are in Section VII.

II. Motivation and Related Work

The demand for computing and engineering professionals is growing, but both the number and the proportion of computing and engineering bachelor's degrees awarded to women have declined [1]. Therefore, the majority of computing and engineering-related jobs will be pursued and filled by men [2, 3]. Addressing the lack of participation of females in computing and engineering will require sustained efforts of a wide range of programs and initiatives. A broad spectrum of strategies has been used to improve female participation in computing and engineering, such as academic exposure, role models and mentors, parental preconceptions and influences, and afterschool clubs for young girls [4, 5, 6]. Social learning is also an effective strategy to engage female students with computing and engineering [7, 8, 9]. Studies conducted by the Association for Computing Machinery (ACM), and the Computer Science Teachers Association (CSTA) revealed that computing and engineering education faces problems regarding lack of exposure and motives, which are essential for the students [6]. Learning opportunities are needed to provide students, especially females, with exciting and challenging activities in positive and fun environments. Therefore, many organizations and institutions run summer camps and academies that attempt to engage students in computing and engineering at an early age. Many of these camps have shown positive changes in attitudes about computing and engineering and/or self-reported knowledge of computing and engineering[10]. Robotics, games, and other educational kits are examples of such applications that have been used extensively for such summer camps. Moreover, educators have developed educational platforms to teach introductory computing concepts; plus, many educational platforms are free and easy to install and maintain. Popular educational platforms include Alice, Scratch, Greenfoot, and GameBox, etc. [11]. *Scratch* is a project developed by MIT Media Lab's Lifelong Kindergarten Group [12]. It is free to download and use. Scratch helps young students and new programmers to acquire and improve computing skills such as creative thinking, systematical thinking, and collaboration [13]. Many organizations and institutions also hosted summer camps using Robotics or other educational kits such as Lego EV3, Raspberry Pi, and Arduinos. The use of Raspberry Pi in classrooms to introduce computing and engineering concepts to students has been successful [14, 15, 16]. Hofstra University offered a camp using Raspberry Pi for students entering grades 4th through ninth [17]. The iDTech offered a course for 10 to 12-year-old students called Build and Code Your Own Take-Home Laptop[18]. This course taught students how to build laptops from a Raspberry Pi and circuit boards that combined hardware and software knowledge for a hands-on approach to integrate programming and engineering concepts. Digital Media Academy hosted a Python & Electrical Engineering with Take-Home Laptop Camp for students aged 12 to 17 to build their Internet-Connected Device using the Raspberry Pi and various sensors [19]. We designed and organized a one-week summer camp for incoming 8^{th}-grade female students in summer 2018. The goal of the summer camp was to offer hands-on experiences that integrated programming and engineering concepts and provided challenging and innovative concepts in learning, problem-solving, analytical skills, and fostering an interest in computing and engineering for middle school females.

III. Camp Organization

We recruited 50 incoming 8th-grade females in summer 2018 for our camp. Texas Workforce Commission (TWC) funded this camp. This grant provided us with an appropriate summer stipend to develop the content and administer the camp.

We have developed partnerships with several local middle schools to help us to recruit female participants. There are pre-requisites for the camp participants, i.e., 8th graders who have finished pre-algebra. Marketing materials such as brochures, flyers, emails, and websites were distributed to local middle schools. Additionally, team members directly contacted local school principals and superintendents and distributed application packages to guidance counselors asking them to forward the summer camp information to teachers and parents. Female undergraduate students were interviewed and hired to serve as camp counselors to help the summer camp. Moreover, accomplished female professionals from surrounding industries and organizations, such as the Society of Women Engineers, the Golden Triangle – Texas Alliance for Minorities in Engineering (GT-TAME), ExxonMobil, and Motiva, were invited as guest speakers to share their professional career experiences for our camp participants.

The camp was held in two computer laboratories at our institution. Participants worked in pairs on one Raspberry Pi starter kit and one computer with hands-on activities, collaborating to enhance learning. To expose female students to the wonder of computing and engineering, a field trip to NASA/Johnson Space Center in Houston, Texas was scheduled on the last day of the summer camp, which provided the participants with an unforgettable lifetime experience, including being introduced to female engineers and astronauts.

The camp started at 9:00 am and ended at 4:00 pm daily with lunch provided at our dining hall. Lab-based hands-on sessions were held for two and a half hours each morning and afternoon. An instructor and two student counselors taught daily lab session. On the final day of the summer camp, participants attended a graduation ceremony in which they received participation certificates and special recognition awards.

We also employed several strategies to enrich our camp such as social encouragement, academic exposure, and the buddy system. For example, the social encouragement is through parent orientation and female professionals' involvement as mentors for the camp participants. Table I lists all the strategies we adopted.

TABLE I. STRATEGIES TO ENRICH THE SUMMER CAMP

Strategies	**Detail**
Social Encouragement	Positive reinforcement of computing and engineering pursuits from family and peers
Academic Exposure	The availability of, and the opportunity to participate in computing and engineering-related activities
Career Perception	The familiarity with, and perception of, computing and engineering as a career with diverse applications and broad potential for positive societal impact
Buddy System /Pair Programming	Participants work in pairs on one Raspberry Pi and one computer, collaborating to enhance learning

Our summer camp started on July 30, 2018 and ended on August 3, 2018. Another goal of our summer camp was to increase the diversity of students in computing and engineering occupations. We attracted underrepresented minorities from local middle schools. Table II shows the program participants by ethnicity.

TABLE II. PROJECTED ETHNIC BREAKDOWN OF THE 2018 CAMP

Ethnic Category	**Number of Participants**
African American	24
Asian	4
Hispanic/Latina	15
White (Non-Hispanic)	3
Two or More Races	1
Not Answered	3

Our summer camp was successful in recruiting over 80% of students from underrepresented groups. 48% of the participants were African American; 30% were Hispanic/Latina; 8% were Asian; 2% were Two or More Races; 6% wished not to respond, and 6% were White (Non-Hispanic). One of our motivations is to increase female participation, especially female minority participation in STEM. Our team reached out to regional school counselors and principals and ask their recommendations for qualified minority students.

Parents of young females are often not aware of what the study of computing and engineering entails, and what careers in computing and engineering are available for their children. A parent/student orientation was conducted before the camp to inform parents about a wide variety of computing and engineering careers that are available for females. Other pre-camp preparations included development and distribution of promotional brochures, application forms, and consent forms, set up the camp website for advertisement, design and order camp t-shirts; order Raspberry Pi 3 starter kits; reserve computer labs; install the software in the labs; develop pre/post assessment; arrange NASA/Johnson Space Center Houston field excursion reservations; prepare teaching materials; arrange dining hall reservations; review application packages and send out acceptance notification; invite female professionals' as guest speakers; interview and select female undergraduate students as student counselors.

For follow up and sustainability of the females' interest in computing and engineering, a Saturday session in Fall 2018 and a Saturday session in Spring 2019 were conducted at our institution to provide cohort participants an introduction to public organization websites that could assist them in forming female computing and engineering after school clubs at their school sites. Saturday, December 8, 2018, was the first follow-up session. The event introduced prior camp participants to computing and animation concepts used by Pixar animators to learn the skills of developing apps. The second follow-up session was held on Saturday, February 23, 2019, as part of a series of sessions to provide challenging hands-on experiences and innovative concepts that introduced problem-solving and analytical skills. Moreover, year-round learning experiences were provided through establishing after-school clubs for females throughout Independent School Districts, which could provide the young females with an opportunity to continue to enhance their experiences in developing computing and engineering skills. By implementing this female-only summer camp, our program intended to create a formula for developing a sustainability model that would continue to generate interest in females to pursue careers in computing and engineering.

IV. CORE CURRICULUM INSTRUCTION

The goal of our summer camp was to integrate and teach fundamental computing and engineering concepts through fun hands-on activities in two series of labs using Raspberry Pi and Scratch. Raspberry Pi labs were in the morning, and game programming labs using Scratch were in the afternoon.

Instructors developed instructional materials, which included PowerPoint slides to highlight concepts, live demonstrations, sample programs, video tutorials, and hands-on activities. Instructors explained key computing and engineering concepts using PowerPoint slides and live demonstrations. Students then worked collaboratively to complete hands-on activities to enhance learning. All hands-on activities were simple enough that students could complete them even with no previous experience. Participants needed no prior knowledge or specific skills. The Raspberry Pi hands-on activities focused on introducing basic computing, electronic, and control engineering concepts.

Female student counselors assisted each pair of our participants to provide application guidance. All participants started with simple hands-on tasks and progressively built up to more complex tasks. Industry professionals from ExxonMobil and BASF also volunteered and worked with the participants throughout the summer camp in collaboration with our institution.

A. Raspberry Pi

We adopted Raspberry Pi as one of our teaching tools for this summer camp. The design of Raspberry Pi encourages young people to learn how to code. The Raspberry Pi 3 Model B+ was the latest product in the Raspberry Pi 3 range [17] in 2018. Any institution that is interested in organizing similar camps can use the same kit, i.e. Raspberry Pi, or cheaper hardware, such as Arduino, or a more kid-friendly robotic, LEGO EV3. Figure 1 is the picture of the Raspberry Pi 3 Model B+ Starter Kit from Sparkfun that we used for our camp [18].

Fig. 1. Raspberry Pi 3 Model B+ Starter Kit from Sparkfun [18]

This starter kit includes:

- Raspberry Pi 3 B+
- SparkFun Pi Wedge
- SparkFun FTDI Basic Breakout --- 3.3V
- Breadboard --- Full-Size (Bare)
- Pi Tin for the Raspberry Pi --- Black
- 16GB microSD (Preloaded with OS)
- microSD USB Reader
- Multicolor Buttons (4 pack)
- Assorted LED (20 pack)
- Resistor 330 Ohm 1/6 Watt PTH
- Raspberry Pi GPIO Ribbon Cable
- SparkFun USB Mini-B Cable
- Wall Adapter Power Supply
- Jumper Wires Premium 6" M/F
- Jumper Wires Standard 7" M/M

Figure 2 displays the details of the Raspberry Pi 3 Model B+ [19]. The Raspberry Pi 3 Model B+ includes a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT [19]. Raspberry Pi has been used for education, home automation, industrial systems, and even the International Space Station [19].

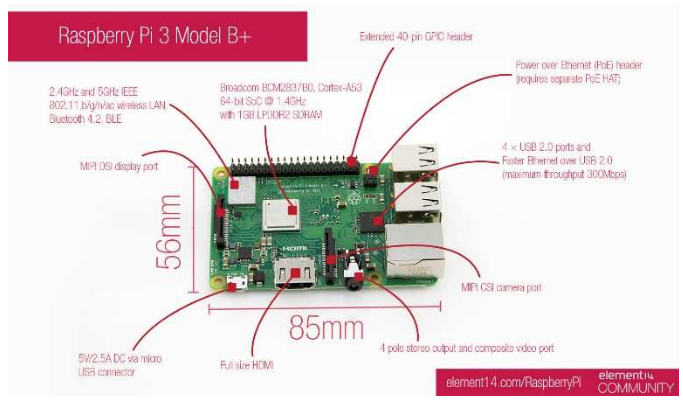


Fig. 2. Raspberry Pi 3 Model B+ [19]

Raspberry Pi allows students to construct a variety of projects using LED lights, buttons, and sensors. Sparkfun offers a free open source of Raspberry Pi. Students can learn to write programs using Python, C, Java, and Perl on Raspberry Pi. We chose Python for our summer camp. This one-week summer camp was for students with no prior experience in Python programming or Raspberry Pi. It adopted a project-based approach where students could build, create and command Raspberry Pi using Python. Instructors designed seven hands-on projects for this summer shown in Table III.

TABLE III. RASPBERRY PI CURRICULUM CONTENT

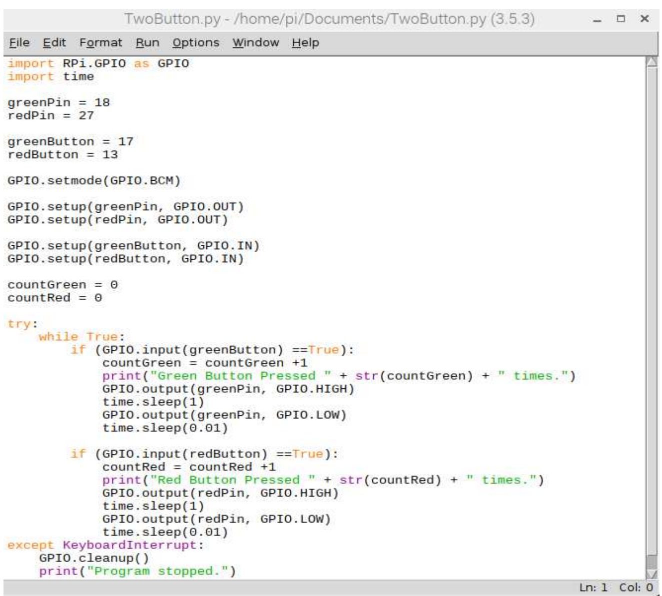
Day 1	Project 1	Set Up Raspberry Pi Starter Kit
Day 2	Project 2	Change LED Light
Day 3	Project 3	Control Two LED Lights with Buttons
Day 4	Project 4	Currency Exchange Rates
	Project 5	NASA Picture of the Day
Day 5	Project 6	Detect and Display Temperature
	Project 7	Create Music with Sonic Pi

For project 1, students began with assembling a Raspberry Pi starter kit, plugged into a standard monitor, keyboard, mouse, power supply, and fitted with an SD-card on the Raspberry Pi. Students then followed along and learned how to install the Raspbian Operating System, how to set up the language and time, and how to connect to a wireless access point. Students explored different interfaces, including the text editor, Python IDLE interface, configuration settings, and the terminal window during the lab session. The learning objectives of this project are to learn how to:

- Install and set up Raspberry Pi
- Connect Raspberry Pi to the internet
- Perform basic system administration command
- Write a Python program on Raspberry Pi

For the second project (Change LED Light), instructors introduced circuits on breadboards. Students learned how to connect their units to FTDI adapters, locate the GPIO and connect their units to the breadboard. Students also learned how to connect the LED light to the board using wires and resistors, and to write a Python program to turn an LED light on and off.

The third project (Control Two LED Lights with Buttons) introduced more complex circuit components and controlling skills. Students used two LED lights, one red and one green, and two control buttons, one red and one green, for this project. Students learned to write a program so that when the user pushed the red button, the program turned on the red LED light, and when the user pushed the green button, the program turned on the green LED light. This project covered basic computing, electronic engineering, and control engineering concepts, such as loops, input, output, and interrupt handling. Figure 3 shows the screenshot of the Python program that one of our students wrote for this project.




```
import RPi.GPIO as GPIO
import time

greenPin = 18
redPin = 27

greenButton = 17
redButton = 13

GPIO.setmode(GPIO.BCM)

GPIO.setup(greenPin, GPIO.OUT)
GPIO.setup(redPin, GPIO.OUT)

GPIO.setup(greenButton, GPIO.IN)
GPIO.setup(redButton, GPIO.IN)

countGreen = 0
countRed = 0

try:
    while True:
        if (GPIO.input(greenButton) ==True):
            countGreen = countGreen +1
            print("Green Button Pressed " + str(countGreen) + " times.")
            GPIO.output(greenPin, GPIO.HIGH)
            time.sleep(1)
            GPIO.output(greenPin, GPIO.LOW)
            time.sleep(0.01)

        if (GPIO.input(redButton) ==True):
            countRed = countRed +1
            print("Red Button Pressed " + str(countRed) + " times.")
            GPIO.output(redPin, GPIO.HIGH)
            time.sleep(1)
            GPIO.output(redPin, GPIO.LOW)
            time.sleep(0.01)
except KeyboardInterrupt:
    GPIO.cleanup()
    print("Program stopped.")
```

Fig. 3. Screenshot of the Python Program

The fourth project (Currency Exchange Rates) was about Application Programming Interfaces (API). Students were instructed to connect the Raspberry Pi to a LAN connection and learned how to use a specific API to calculate the exchange rates. Students then wrote a program to convert $35.50 in USD to Euros and display the amount on the console. Students could manipulate their programs to compute the exchange rates between different countries worldwide.

For project 5 (NASA Picture of the Day), students learned how to write a Python program to connect automatically to the NASA web service, download and save NASA's Picture of the Day (APOD) into a specific folder using API.

The sixth project (Detect and Display Temperature using Sensor) was about connecting and controlling sensors through Raspberry Pi. Instructors introduced a series of different sensors. Students were then given a temperature sensor, TEMP102 chip, and learned to write a Python program that detected and displayed the air temperature around the Sensor connected to their Raspberry Pi.

The last project (Create Music with Sonic Pi) was to create music with Sonic Pi on the Raspberry Pi. Sonic Pi is a free code-based music creation and performance tool. Students learned to program creatively by composing or performing music on the Raspberry Pi.

We integrated basic programing and engineering concepts in those hands-on projects for a one-week summer camp in 2018.

B. Scratch

The introduction of computing concepts and skills using Scratch included the following topics: an introduction to Scratch, arithmetic and Boolean operations, control structures, and basic data structures. Scratch is known as a popular programming language that eliminates the frustration of syntax errors, usually present in beginners' work. Instructors designed eight hands-on projects for this camp. A summarization of these projects is in Table IV. For example, the Random Number Guessing Game Project was used to demonstrate how to write a program to generate pseudo-random numbers. Students were asked to write a game in Scratch to generate a random integer from 0 to 9 and let the player of the game guess what number was generated.

TABLE IV. SCRATCH CURRICULUM CONTENT

Hands-on Project	**Programming Concept Covered**
Introduction to Scratch	Project Creation
Sound Animation	Variable, String, Animation
Movement Animation	Objects, Motion, Animation
Random Number Guessing Game	Variables, Mathematical operators, Logical operators, Control structures
Cat & Bell Game	Conditional Logic, Loops, Control Structure, Animation
Crazy Eight Bell Game	
Animal Movie Project	
Doodle Drawing Project	

Figure 4 shows a screenshot of the Scratch program that one of our students wrote for this project. This project demonstrated the student's capability of understanding basic programming concepts such as variables, mathematical operators, logical operators, and control structures.

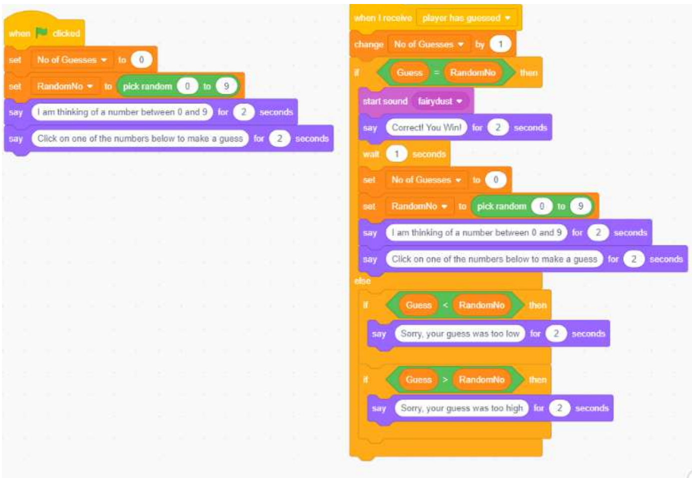


Fig. 4. Screenshot of Scratch Programming

V. Assessment

Assessment plays a foundational role in education and was approachable in a variety of ways. We adopted informal assessment for our program. Consent letters asking permission to collect data from survey questionnaires were sent to the parents before the summer camp started. All camp participants were provided an online evaluation instrument on the last day of the summer camp. All participants were informed that the pre/post evaluation survey consisted of a five-point scale of knowledge acquired where 1 is the lowest score and 5 is the highest score on their score sheets. The average rating for each intervention method was based upon the net gain value: where 0 - 0.99 means does not meet the standard, 1.00 -1.24 meets standard; 1.25- 1.49 is good, 1.50-1.74 is excellent, and 1.75 and above is outstanding. Participants completed pre/post questionnaires that measured students' self-reported interest and knowledge. The questionnaire also asked participants what was their most and least favorite part of the summer camp, what could be done to improve the summer camp, and comments about their experience of learning computing and engineering skills as a female. A sample questionnaire is shown in Table V. A partial list of students' responses for each open question is summarized in Table VI.

The assessment results of the scale-based questions are shown in Figure 5, which reflects the responses of all participants of the 2018 8th-grade summer camp. The assessment results show a significant increase in knowledge of all camp-related topics. Table VII lists the gain value of the assessment. Figure 6 visualizes the assessment result. For 50 incoming 8th-grade females who participated in this summer camp, a noted significant increase of knowledge of camp-related topics was in the students' assessment report, which averaged a gain value standard of 2.50 that reflects an outstanding gain value. The lowest score on the assessment instrument, "knowledge of how to use computers," can be attributed to the fact that most students are already familiar with basic computer technology skills.

TABLE V. Sample Pre/Post-camp Questionnaire

Please check a box to rate yourself in each of the following areas:	1	2	3	4	5
RASPBERRY PI					
Knowledge of Raspberry Pi 3					
Knowledge of Raspberry Pi 3 hookup procedure					
Knowledge of programming Raspberry Pi 3					
GAME PROGRAMMING					
Knowledge of types of games					
Knowledge of game programming					
Knowledge of game design					
Knowledge of game resources					
SCRATCH					
Knowledge of animating scenes with Scratch					
Knowledge of programming concepts with Scratch					
Knowledge of Scratch programming					
COMPUTING AND ENGINEERING					
Knowledge of how to use computers					
Knowledge of computing and engineering careers					
OPEN RESPONSE QUESTIONS					
Below, please give us your written comments about the summer camp.					
As a result of attending this camp, will you take Computing or Engineering classes later? ____ Yes ___No					
As a result of attending this summer camp, would you like to pursue a career in Computing or Engineering? ____ Yes ___No					
Would you recommend this summer camp to a friend? ____ Yes ___No					
What suggestions do you have for improving the summer camp?					
What did you like most about the camp?					
What did you like least about the camp?					
Please comment about your experience of learning new computing and engineering skills as a female.					
Please write any other comments you may have.					

TABLE VI. PARTIAL LIST OF STUDENTS' RESPONSE TO OPEN QUESTIONS

Question 1: What suggestions do you have for improving the camp?

- I think that the camp is already great!
- More time working on a project
- Make classes 2 weeks instead of 1 week
- To have more time than just a week in the camp
- The camp was amazing and really beneficial.

Question 2: What did you like most about the camp?

- I liked that there was a lot of hands on activities.
- One thing I liked the most was the Raspberry Pi.
- I enjoyed learning about the Raspberry Pi.
- You get to learn things you might not learn at school
- Building the Raspberry Pi and Bread Board
- Gaming Programming
- The high level of education distributed by the teachers
- What I liked the most was the hands-on activities in computer and projects.
- It was really interesting and I definitely have to think about having a future in this.
- What I liked the most about the camp was wiring the bread board to the Raspberry Pi.

Question 3: What did you like least about the camp?

- Nothing, everything was great
- Want more classes, days to short, wanted to learn more
- I wish the Raspberry Pi could have been longer.
- What I liked the least was that I wish we had more time.
- The Scratch class could have been longer.
- I really have no complaints about the camp. It was really fun.
- I wanted to learn more but we only had a week for the camp.

Question 4: Please comment about your experience of learning new computing and engineering skills as a female.

- coding/programming skills as a female.
- AWESOME!!!
- It was really fun to learn new things about coding.
- They need more women in coding and programming and I would like to be a part of that.
- Learning new programming was an awesome experience.
- I feel that it was good to start this camp so young females like us will not be
- scared to become someone in the computer science field.
- It taught more about a career that I could possibly show interest in, in the future.
- I do feel more accomplished because not many females go into or learn this area of work.
- The teachers were very good and the classes were not missing resources.
- I feel like it raised my chances of going into computer science.
- My experience about being a female in the camp was fun and when people think

Question 5: Please write any other comments you may have.

- The camp was fun.
- This camp was very interesting and taught you many things about computer science and engineering.
- It was a very informational camp.
- This camp was very fun.
- I like that we had to make our games from Scratch.
- I enjoyed the camp.
- I would have liked to have had a little more time on some of the things.
- I think this coding camp will help a lot of people learn about coding.
- I really loved learning this and it was really interesting.
- It was very exciting!
- I enjoyed everything and the teachers were great.

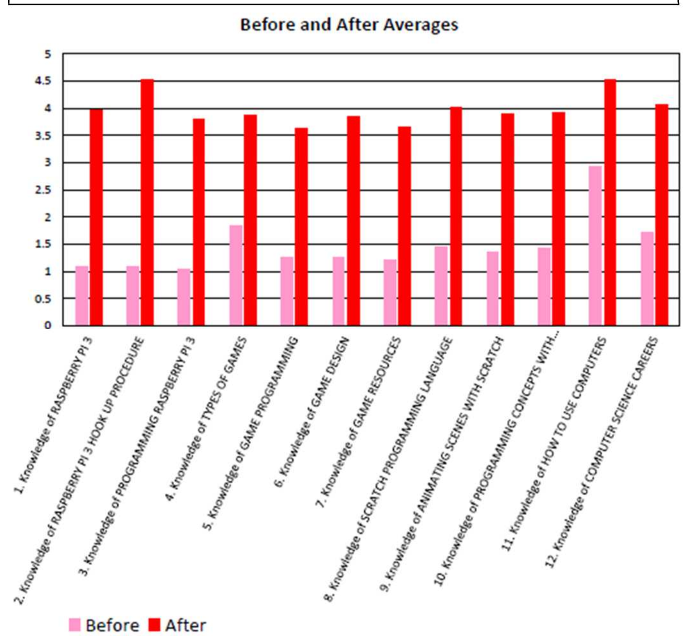


Fig. 5. Before and After Average of Assessment Questions

TABLE VII. ASSESSMENT RESULT

Assessment Questions	Gain Value
Knowledge of raspberry pi 3	2.90
Knowledge of raspberry pi 3 hook up procedure	3.44
Knowledge of programming raspberry pi 3	2.75
Knowledge of types of games	2.04
Knowledge of game programming	2.35
Knowledge of game design	2.60
Knowledge of game resources	2.44
Knowledge of animating scenes with Scratch	2.54
Knowledge of programming concepts with Scratch	2.50
Knowledge of scratch programming language	2.56
Knowledge of how to use computers	1.60
Knowledge of computing and engineering careers	2.33

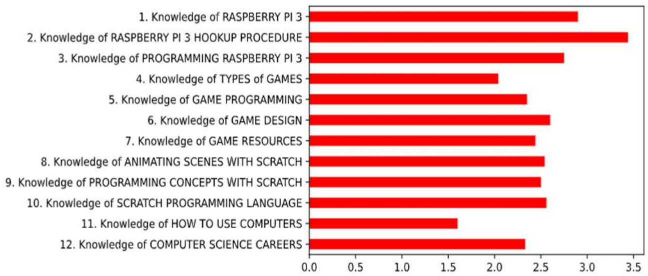


Fig. 6. Visulization of the Assessment Result

VI. First-Year Experience and Lessons Learned

Our one-week summer camp for 50 incoming 8th-grade females was very successful. Participants obtained a better understanding of principle computing and engineering concepts and confidence in computing and engineering. However, our experience did reveal a few areas that need improving. A description to benefit those who plan to conduct similar summer camps at their institutions is below.

Based on participants' feedback, the basic structure will remain the same for future summer camps. The instructional methods will also be retained. However, the participants commented that the one-week summer camp was too short. The possibility of extending the summer camp to multiple weeks will be explored. An independent formal assessment is a very valuable tool for improvement. We plan to conduct a formal assessment for future camps.

VII. Conclusion and Future Work

During the summer of 2018, a weeklong summer camp using Scratch and Raspberry Pi was offered for fifty incoming 8th-grade females at our institution. This summer camp focused on integrating programming and engineering concepts using Raspberry Pi and Scratch. Students learned problem-solving skills and basic computing and engineering concepts from hands-on experiences. Based on the strong interests of students and parents as well as positive survey feedback, we concluded that the summer camp was very successful. All in all the article is replete with information and will help others replicate the project.

In spring 2020, our team won the Texas Workforce Commission Award again and planned to host similar summer camps in summer 2020 for middle school female students. Unfortunately, we had to cancel the camp because of the pandemic.

In spring 2021, we won the Texas Workforce Commission Award and plan to host similar summer camps and one residential STEM camp in Summer 2021 for both middle school and high school students to increase their interests and knowledge of STEM, especially computing and engineering.

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