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Developing an AI and Engineering Design Hybrid-Remote Summer Camp Program for Underrepresented Students (Evaluation)

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Developing an AI and Engineering Design Hybrid-Remote Summer Camp Program for Underrepresented Students (Evaluation)

Abstract

This paper evaluates creation and implementation of a hybrid-remote (the partial remote instruction of in-person students) summer camp curriculum developed using an Inquiry-Based Pedagogical Model for underrepresented students to gain relevant Data Science and Artificial Intelligence (AI) concepts. In the field of AI, diversity is key to improving data sets and is crucial to avoiding detrimental bias outcomes, making it essential that underrepresented students are provided with opportunities to participate.

In the Summer of 2023, the Engaged Quality Instruction through Professional Development (EQuIPD) grant from the University of Florida assisted Upward Bound/UNITE with curriculum creation and remote delivery for a camp serving underrepresented minority (URM) students, being held at Miami Dade College, located in one of the largest education districts in the United States. Upward Bound is a U.S. Department of Education grant program aimed at serving low-income underrepresented middle and high school students. The camp served 30 students from the Miami Dade school district, selected by Upward Bound at Miami Dade College. While the camp presented four educational topic classes to build student knowledge, the EQuIPD grant was responsible for development of two additional classes covering Artificial Intelligence (AI) and Python Programming. Each class occurred twice a week for one period each on the same day. The grant developed curriculum for AI/Data Science and Computer Programming classes, created teacher instruction guides and resources for the classes, and remotely instructed the Programming section using college mentors and grant staff.

The goal of curriculum developed by the EQuIPD grant was to seamlessly tie concepts and real-world applications of AI with the practicality and creativity of computer programming. Students were taught a variety of problem-solving methods and design concepts, ethics, and responsibilities as they relate to AI, conceptualization of AI processes and chatbot principles, Python programming basics, and construction of programs. These two classes worked alongside each other, culminating in students being able to develop and present their own musical artist personalized rules-based chatbot. After the programs, students were surveyed on their experiences and desire to continue education in Programming and AI, which was analyzed and reflected upon to determine refinement for future iterations of this curriculum.

This paper will focus on the following aspects of this cooperation: (1) How can we utilize an Inquiry-Based Pedagogical Model to encourage future learning and application of information for foundational AI and computer programming? (2) How can we incorporate various methods of thought such as systems thinking, engineering design, computational and algorithmic thinking

to teach students efficient problem solving and draw the connection between the art of programming with concepts of AI? (3) How can we use cloud-based interactive tools to expand student access and equity and serve underrepresented youth to develop confidence to pursue data science careers through relevant industry knowledge? (4) What parts of the developed curriculum were found adequate by students, and which areas need to be improved?

Feedback was obtained from student qualitative post-survey data via Qualtrics and communication with in-person instructors of the AI curriculum to determine the effectiveness of the hybrid-remote structure to refine the course for future implementation.

Purpose

The purpose of this paper is to evaluate the impact and effectiveness of a hybrid-remote summer camp curriculum and assess crucial aspects of its implementation to improve its organization and execution in future iterations. The primary goal of this curriculum is to provide a pathway for underrepresented minority (URM) students to gain experience with Artificial Intelligence (AI) and Programming topics, equipping them with relevant knowledge and inspiring them to pursue future careers in the industry.

Owing to the potential of AI systems to reduce workloads and expand the capacity of various public services, AI is being integrated in an increasing number of industries, ranging from healthcare, law enforcement, department stores, to aspects of the judicial system [1,2]. These services are an integral part of citizens' lives, and the outcome of these AI algorithms can be detrimental if not developed and trained adequately.

The most crucial detail in developing these AI algorithms is providing highly representative data to make accurate and reliable predictions. If the training data is not as diverse as the data the algorithm is utilized on, the predictions will be inaccurate. This creates unintended bias towards the unrepresented data, often resulting in real-world consequences for URM populations [3]. For instance, many facial recognition and pedestrian detection programs perform worse on individuals with darker skin tones, resulting in outcomes that can be offensive, such as incorrect labeling, or even dangerous if used in machinery such as a self-driving vehicle [2].

Visualizing the tech industry demographics, it is apparent that many of the existing biases in AI reflect a similar disparity in training data. While the STEM (Science, Technology, Engineering, and Mathematics) field has seen an increase in diversity in the past decade, it still retains large gaps in representation, with URM individuals accounting for 26% of science and engineering bachelor's degrees in 2020, and individuals that identify as female remaining underrepresented in a variety of STEM majors [4]. These disparities largely originate in pre-college learning, with many URM students not being guided to STEM focused pathways [5]. To combat this, URM students must be encouraged to follow these pathways, provided with more impactful learning opportunities, and given access to necessary tools and technology to be successful in STEM fields [5,6].

This paper hopes to evaluate how this hybrid-remote summer camp curriculum may address some of these barriers through answering the following research questions:

> **RQ1.** How can we utilize an Inquiry-Based Pedagogical Model to encourage future learning and retainment of information?
> **RQ2.** How can we incorporate various methods of thought such as systems thinking, engineering design, computational and algorithmic thinking to teach students efficient problem solving and draw the connection between the art of programming with concepts of AI?
> **RQ3.** How can we use cloud-based interactive tools to expand student access and equity and serve underrepresented youth to provide confidence to pursue data science careers through relevant industry knowledge?
> **RQ4.** What parts of the developed curriculum were found adequate by students, and which areas need to be improved?

Literature Review

The cornerstone of the curriculum developed for this hybrid-remote summer camp is an "inquiry-based pedagogical" model, which acts as outline for all curriculum developed by the Engaged Quality Instruction through Professional Development (EQuIPD) grant and was shown to create change to teacher practices and met What Works Clearinghouse (WWC) metrics for strong impact [7].

In this section, we will analyze the current implementation of such models, as well as remote learning and cloud-based tools within STEM curriculum with the goal of providing background knowledge on current efforts towards wider accessibility and improved student outcomes.

Inquiry-Based Pedagogical Models

Learning approaches are an indispensable component in ensuring that students' acquisition of information is streamlined and not subject to potential misconceptions obtained from experience. For example, traditional lecture-based approaches are vulnerable to misinterpretations by the student due to possible lack of association between the concepts, leaving room for inaccurate mental models to be formed [8]. According to Healey et al., higher education environments rely too much on this approach instead of allowing students opportunities to establish their own relationships between concepts [9]. Comparatively, a learning environment where inquiry is a critical component of instruction can foster student curiosity, formation of hypotheses, and engagement with the material expressed in thought processes unique to the individual [8]. As such, the emphasis in inquiry-based learning on asking questions, analyzing material, associating data with logical conclusions, and researching to formulate explanations can remedy problems with knowledge acquisition. However, rather than focusing on a single teaching method, incorporating inquiry-based learning into traditional lecture-based teaching can be used to complement the wide variety of learning styles among students [9].

Cloud-Based Technology in Education

It has been found that the use of technology in the classroom promotes effective learning by giving students the ability to conduct their own research. In doing so, they encounter realistic challenges during the learning process [10]. The need to combine face-to-face instruction with online learning has given rise to the concept of blended learning [10]. Using cloud-based infrastructure for this type of teaching modality can mitigate accessibility issues for underrepresented groups of students. Choosing technology that does not require local computing allows students a degree of schedule flexibility by giving them access to all needed resources from any location with internet access [11].

An example of the usage of cloud-based tools supplementing traditional educational approaches is the implementation of "bootcamp laboratories" that were introduced as part of a hybrid transfer program in the Microbiology and Cell Science (MCB) Department at the University of Florida [12]. These bootcamp laboratories proved effective in increasing student engagement, namely due to students finding the hybrid approach adequately balanced with hands-on experiences. These findings demonstrate that the hybrid approach can be effective at mitigating some of the limitations of remote instruction, particularly the drop in student engagement due to the lack of direct learning interactions. At the same time, the remote component of the program was still important in providing students with the necessary preparation for the five-day experience. Students found the mixed approach of traditional and bootcamp-style laboratory courses challenging due to the uniqueness of the program and potential time constraints brought about by the bootcamp experience. They did, however, agree that such an approach provided a better learning experience due to the "continuity of the experience" and the emphasis on teamwork relevant to real-world scenarios in the field [12].

The Benefits and Pitfalls of Remote Learning

Compared to the hybrid approach, camps that are delivered entirely remotely provide unique benefits and shortcomings. An example of this is the Gains in the Education of Mathematics and Science (GEMS) program hosted by the Walter Reed Army Institute of Research, whose program was converted to a remote environment in 2020. Overall, the program received positive participation levels from a wide range of demographics, interest in STEM programs, and satisfaction from the mentorship provided compared to the traditional in-person program. At the same time, numerous challenges with student engagement arose. The transition to a remote environment proved to be a limiting factor for students that were seeking a more immersive experience, as well as a drop in the amount of group work and interaction required in a traditional program. The requirement of high-speed internet posed another challenge to student participation, given that it may not be readily available to all participants. The results of the remote transition in this example demonstrate the need for remedies that encourage active student participation, such as the delivery of take-home experiment kits for distance learning and an online curriculum that encourages communication between students [13].

Organization Background

Upward Bound is a TRIO program as part of a United States Department of Education Grant to local educational associations or consortia. Upward Bound provides precollege students the opportunity to develop skills, knowledge, and training to help them succeed in their current academic setting and prepare them to be successful in higher educational settings. Upward Bound serves high school students from low-income, low-resourced families or families where neither parent holds a bachelor’s degree. Upward Bound goal is to remove barriers for students seeking higher education and to improve the rate at which students complete secondary education and earn a degree in a postsecondary institution. Upward Bound programs are required to provide instruction in math, lab sciences, composition, literature, and a foreign language. These programs generally have multiple meetings throughout the school year and some kind of summer immersive program over the summer [14].

Camp Information and Selection Process

The camp being discussed took place from June 19, 2023, to July 28, 2023, at the Miami Dade College Homestead Campus and was organized and conducted by the Upward Bound/UNITE program where it had been run for many years. All students who attend the camp are enrolled in the Homestead Upward Bound/UNITE program which requires students to meet one of the following qualifications: considered low income/income eligible by TRIO federal guidelines, be a potential first-generation college student with neither parent having received a four-year bachelor's degree, or they must be at “high academic risk”. High academic risk refers to students who have not passed an English or Math portion of a given proficiency exam, possess a GPA that is 2.5 or lower, or not having successfully completed an Algebra 1 course by the start of the 10^{th} grade.

Student Demographics

The summer camp had a total of 28 students attending, with 11 of these students identifying as male and 17 of them identifying as female. The camp consisted of grades 8-11 with: three 8^{th} graders, nine 9^{th} graders, ten 10^{th} graders, and six 11^{th} graders. The majority of students attending the camp identified as Black/African American (18), with 9 students identifying as Hispanic/Latino, and 1 student as multiracial. Nearly all students attending the camp were first-generation college bound (27) and received free or reduced-price lunches (24), and half of all students (14) reported that English was not their first language [Fig. 1].

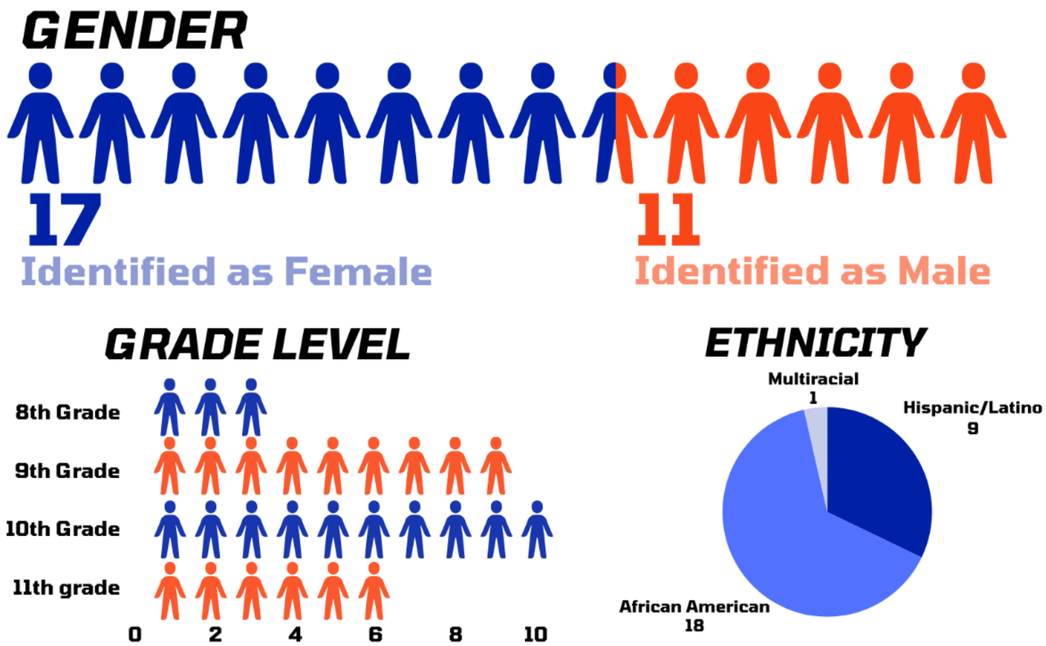


Figure 1. Camp Student Demographics

Curriculum Overview

Development

This section aims to answer the following research question:

> **RQ1.** How can we utilize an Inquiry-Based Conceptual Model to encourage future learning and retainment of information?

This curriculum was developed with the method of hybrid-remote delivery in mind, separated into 2, 75-minute sections of the camp's schedule, with Python Programming Sections taking place in the morning and AI Sections taking place in the afternoon [15]. These sections both took place on Tuesdays and Thursday, consisting of 10 sections of each in total [Tab.1]. While the curriculum for both sections were developed by the EQuIPD grant, the Programming section was instructed by the EQuIPD grant remotely to students present in an in-person classroom setting, and the AI Section was taught entirely in-person by a college teacher working for the program following "teacher guides" containing swim lane instructions and background resources for the topics using our pedagogical model.

Table 1. Curriculum Outline for the Programming and AI Sections by Topic

<table>
<tr><th>Section Number</th><th>Programming Section</th><th>AI Section</th></tr>
<tr><td>1</td><td rowspan="2">Introduction to nanoHub, Jupyter Notebooks, and Python</td><td>Introduction to AI with Systems Thinking</td></tr>
<tr><td>2</td><td>Intelligence in AI</td></tr>
<tr><td>3</td><td>Data Types & Operators</td><td>Ethics in AI – Part 1: Responsibility in AI</td></tr>
<tr><td>4</td><td>Data Structures: Lists & Tuples</td><td>Ethics in AI – Part 2: Perspective & Diversity</td></tr>
<tr><td>5</td><td>Data Structures: Sets & Dictionaries</td><td>Engineering Design & Process Maps</td></tr>
<tr><td>6</td><td>Coding Logic Part 1: Booleans & Operators</td><td>Introduction into Rule-Based Chatbot</td></tr>
<tr><td>7</td><td>Coding Logic Part 2: Conditional Statements</td><td rowspan="2">Chatbot Conversation and Process Mapping</td></tr>
<tr><td>8</td><td>Functions: Wrapping up your Musical Chatbot</td></tr>
<tr><td>9</td><td rowspan="2">Finalizing the Musical Chatbot</td><td>Fine Tuning the Musical Chatbot</td></tr>
<tr><td>10</td><td>Presenting your Chatbot</td></tr>
</table>

Consistent with all curriculum material developed by the EQuIPD grant, both sections follow an inquiry-based pedagogical model that focuses on students participating more actively in their learning through engaging questions with open-ended answers. The curriculum lessons following this structure can be broken down into four main sections: Elicitation, Development, Deployment, and Refinement. The entire curriculum had a relevant wrapper (theme), and in this case, it was the development of a rules based chatbot for a musical performer or group of the students' choosing that had enough PG lyrics to be used as responses by the chatbot.

The first of these sections, Elicitation, focuses on relating the topic of the lesson to students' previous knowledge and "building up" to the material before new connections are made. Elicitation also serves to inform the instructor as to what the students understand about the topic before it is taught. This is best done with an introductory activity that has students discuss an open-ended question or scenario that results in them explaining their current understanding of concepts and definitions in their own words. Instructors can actively participate in this section by encouraging students to reflect on past experiences or previous related topics, allowing students to create their own relationships and models for real world concepts, establishing a concrete foundation for the lesson.

In the pedagogical model employed, Development is where students can analyze new information provided to them and answer questions that assist them in molding and building upon their existing mental models for the lesson concepts. This often includes direct instruction.

The deployment section allows students to further reflect/refine on what they have learned and to continue to iteratively develop their mental model of the concepts through hands-on engagement with the model. This is done through completion of inquiry-based activities that test limits of student understanding in addition to participating in open discussions with classmates to analyze other's processes and generate questions. Ideally, deployment is focused on a real-world or workforce application of the conceptual model to understand the limits and boundaries of the conceptual model.

The final stage of the pedagogical model is Refinement, which is focused on students refining the conceptual model they tested in the deployment stage. This section focuses on the limitations of their models and how they must adapt when provided with new information and what information may be irrelevant. Instructors can support students during this step by guiding them to reflect on how their conceptual model evolved, as well as how models may change when applied to a variety of scenarios.

Through this inquiry-based pedagogical model, the goal is that students will build knowledge from their own perspective, creating a more cohesive and logical flow that will contribute to better retainment of the concepts as well as make future learning more approachable.

In addition to a focus on the efficacy of the curriculum through use of the inquiry-based pedagogical model, this curriculum also had the goal of being widely accessible to support URM students with restricted technology availability. This was met using cloud-based computing in the form of "nanoHub", enabling students to run the required applications for the programming section without needing to install software or run it locally [16]. This can be an advantage compared to requiring a local installation of an application since students only need an internet connection, a nanoHub account, and approval to access the website (such as from the school district). Furthermore, this allows lower-end hardware to run programs more efficiently, minimal initial setup prior to student-use, and allows students to access their work from other computers such as at home or libraries.

For the purposes of the programming section of the curriculum, students utilized nanoHub to run the tool "Jupyter Notebook", where they created, stored, and ran their own Python code, including the creation of their own rules-based chatbot. Jupyter Notebook is a simple tool for coding as it allows the user to make their projects easier to read, debug, communicate through images, texts and hyperlinks. Notebooks also have segment code blocks, which readily visualize outputs, and allow for detailed notes, comments, or instructions in formattable blocks [17]. Using this tool, it is easier for students to visualize their code in digestible chunks, ideally contributing to a better understanding of their code, easier modifications, and an overall better framework for iterative design.

Content Connectivity

This section aims to answer the following research question:

> **RQ2.** How can we incorporate various methods of thought such as systems thinking, engineering design, computational and algorithmic thinking to teach students efficient problem solving and draw the connection between the art of programming with concepts of AI?

The camp curriculum covered concepts from both AI and Programming in their respective sections, with the goal of drawing connections between the two to establish relationships and logical pathways to make understanding the concepts more approachable. In the diagram below, the connection between the main topics discussed in these sections can be seen, with the overall goal of developing a rules-based chatbot being the main deliverable that students created through an understanding of both sections' contents and presented during the final section [Fig. 2].

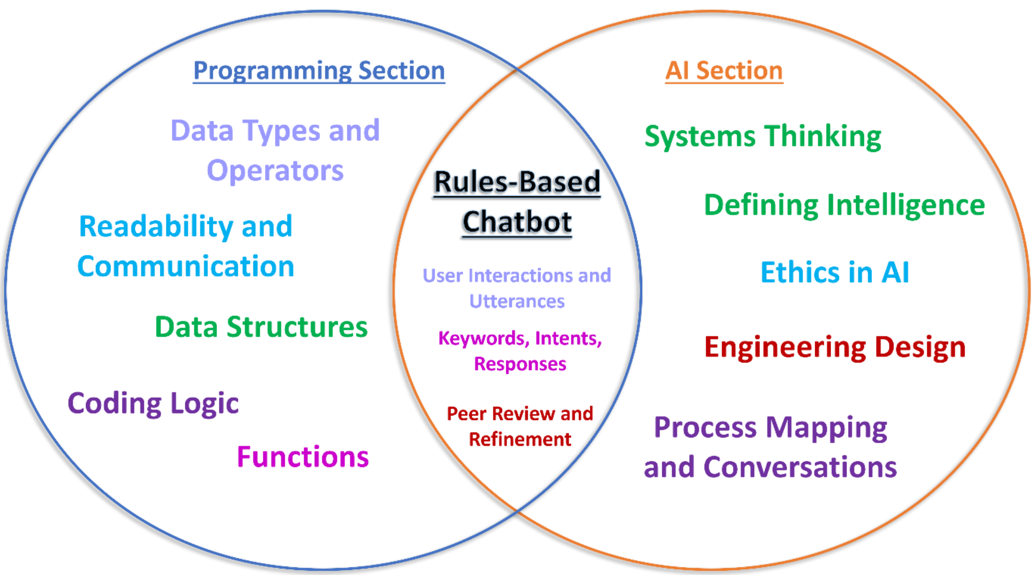


Figure 2. Curriculum Topics Organized by Connectivity

This curriculum started with a crucial part of the inquiry-based approach by having students create their own relationships and definitions for key topics, which can nicely be integrated into the systems thinking approach [Fig. 3].

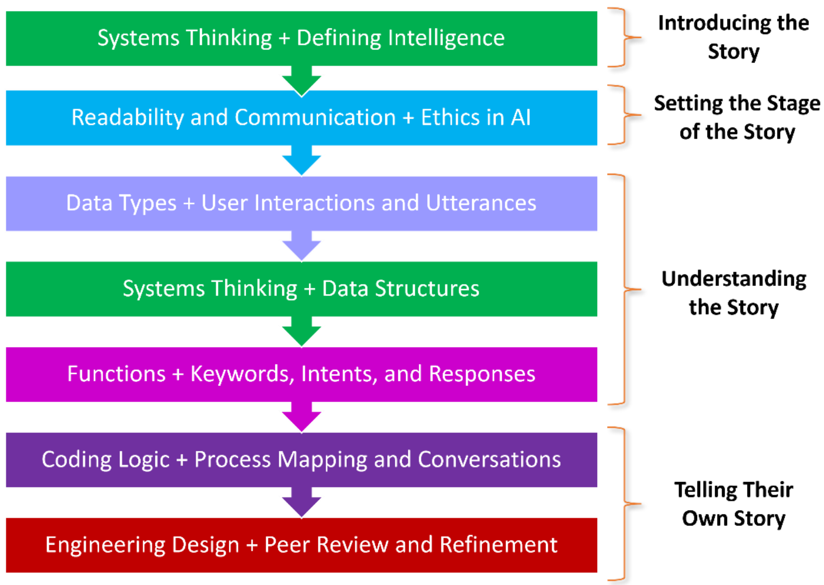


Figure 3. Process Map of Key Topic Connections

Introducing students to the concepts of AI can be confusing, especially when there are many preconceptions for what AI may entail. Allowing students to use systems thinking to create distinctions and deconstruct the parts of what makes AI both “artificial” and “intelligent” establishes a stronger foundation than introducing a traditional concrete definition. Introducing the concept of systems thinking at the beginning of the curriculum also provides them with an important problem-solving tool that can be used to deconstruct scenarios and digest new topics as they progress through the sections.

After this foundation was established, relevant ethical concerns of AI and the responsibilities of its designers were discussed. Much of this section highlights the need for AI process and algorithms to be transparent to its users and other creators in the field. The largest barrier to this transparency is poor communication amongst creators of AI and the “abstraction” of AI algorithms that are the backbone of these models. Abstraction refers to the simplification of programs with the goal of reducing their complexity, however this can be harmful when such programs are used to make impactful decisions and provide little reasoning for the outcome. While learning about these issues, students simultaneously were introduced to the importance of readability in their own programs and were given the opportunity to reflect on how tools such as Jupyter Notebook provide a way for programmers to communicate more effectively.
As the programming section covered essential Python topics such as data types, data structures, and functions, as outlined by blocks three through five in the process map, they were also learning key elements of the rules-based chatbot they would be creating in the AI section [15, Fig. 3]. Through already understanding the building blocks of Python, students can connect the key concepts of rules-based chatbots and how users interact with them to individual components in their code. In terms of programming, “data types” dictate how the data is interacted with,

“data structures” dictate how the data is stored, and “functions” dictate how the data is processed; all of these are essential operations that take place within their rules-based chatbots. Understanding how these elements interact in Python makes learning their AI counterparts much more digestible: “utterances” as the data input by the user, “keywords” as data being searched for by the program, “intents” as indicators of what data to retrieve, and “responses” as the data being output to the user [Fig. 4].

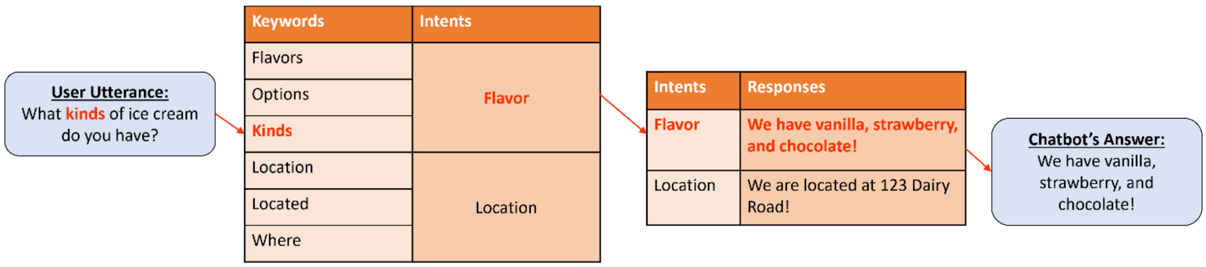


Figure 4. Diagram of a Rules-Based Chatbot

Lastly, students used the tools they developed over the course of the curriculum to tell their own story by constructing a rules-based chatbot, that responds to users with lyrics from their favorite musical artist based on keywords in the questions asked to it. Students started the ideation and design of their chatbot in the AI section by creating process maps of how conversations are structured, which they could implement using the coding logic from the programming section. Following the iterative engineering design process, students created a first draft of their chatbot and were given time to improve on it after receiving feedback from peers before their final presentations.

Delivery

This section aims to answer the following research question:

> **RQ3.** How can we use cloud-based interactive tools to expand student access and serve the underrepresented youth to provide confidence to pursue data science careers through relevant industry knowledge?

The programming section was taught in a hybrid-remote manner with students and a teacher present in a classroom at Miami Dade College and participating in a Zoom session with two instructors from the EQuIPD grant. Zoom was chosen due to its reliability and popularity as an online modality tool and widely used in the school systems. The programming section was organized entirely in Jupyter Notebooks that students were given by camp organizers after being sent by the EQuIPD grant via email communications for upload into the student learning portal. Instructors were able to use Zoom to share their screens and walk through the Jupyter Notebook, which contained elements of all four sections discussed in the inquiry-based model with open-ended assessment “brainstorming” and “reflection” questions positioned periodically throughout the curriculum. Another advantage of Zoom is the ability to create “breakout rooms” which are useful for when students need individual help during activities. Dissimilar to completely remote learning environments, the hybrid approach also allowed for more collaboration between students, with those more confident with the material being able to help others overcome misconceptions of the topics with feedback from the remote instructors

Furthermore, the programming section of the curriculum made use of cloud-based technology, nanoHub, to avoid barriers with installing local applications on the school computers [16]. Utilizing these tools also comes with the advantage of students being able to access their files and continue working outside of the classroom, as long as they have connection to the internet. This access is important for students who may not have personal computers or computers with strong local computing power, who can now utilize any computer with internet access, such as systems at the public library, and be able to access their work or create their own projects. Giving students access to these tools and encouraging their use can promote confidence in their skills through exploration of their features and industry relevant tools and applications that are hosted on the site.

The AI section was taught completely in-person without members of the EQuIPD grant present, apart from one instructor attending the final section time virtually to watch and assist with presentations of the chatbots. For this section, the camp organizers hired their own instructor, while curriculum was provided by the EQuIPD grant. The grant developed a professional development (PD) model to prepare the teacher to support the AI course, but the teacher was hired by the program too late to implement the PD model. To supplement the curriculum material, teacher guides were provided which outlined each section’s material in accordance with the four sections of the inquiry-based pedagogical model: Elicitation, Development, Deployment, and Refinement. Each of these four sections had swim lane process maps that detailed ideal “teacher moves” and “student moves” in chronological order, with external resource links included to provide background context on the material to the instructor. In combination with this, PowerPoint presentations were provided for each section with slides grouped into these four categories to align with the teacher guides. Student handouts were adapted from the PowerPoint information and questions and activities were included, with many asking students to form groups and participate in discussions to facilitate collaboration.

Data Collection

Data collection was conducted via surveys and interviews of students, teachers and facilitators that participated in the camp. The student post-survey took place closely after the camps conclusion, and the student follow-up survey and facilitator interviews were conducted later in the Fall, highlighted by the timeline below [Fig. 5.].

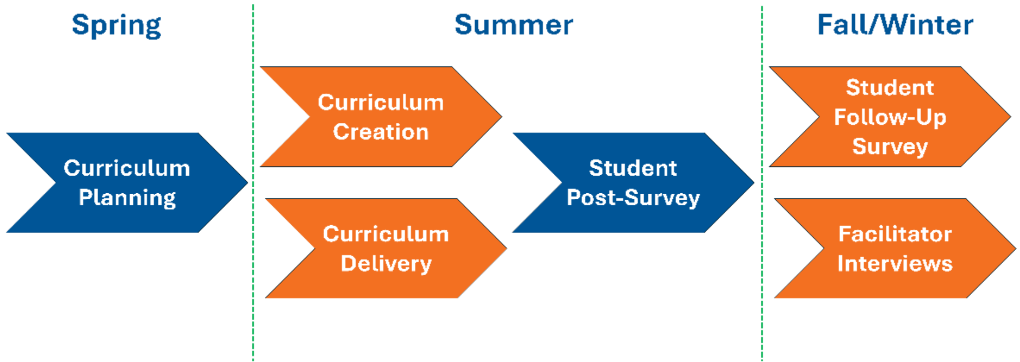


Figure 5. Timeline of the Camp Program and Data Collection

Post Survey

The first survey was created using Qualtrics by the EQuIPD grant and sent to all 28 students on July 26, after the completion of all AI and Programming Sections, by the Upward Bound grant director overseeing the camp operations and received 16 responses [18]. The goal of these questions was the following: basic student information such as grade and programming and AI experience, student's experience with the camp and their perceived understanding of the material, their interest in pursuing STEM topics, and general feedback [Tab. 2].

Table 2. Student Post-Camp Survey Questions by Category

Survey Question	Student Information	Student Knowledge	Student Experience	Student Interest
Q1. What grade are you entering when school begins in the fall?	X			
Q2. How much experience with coding did you have before this camp? (Likert)		X		
Q3. Were you aware of AI before this camp? (Select all that apply)		X		X
Q4. How would you rate your following experiences? (Content, Instruction, Overall Experience out of 5)			X	
Q5. How much do you feel you have learned about Programming and Python in general? (Likert)		X	X	
Q6. How much do you feel you have learned about AI in general? (Likert)		X	X	
Q7. How interactive was the material in class? (Did it draw your attention?) (Likert)			X	
Q8. Would you like to continue learning about AI or				X

Programming concepts in the future? (Select all that apply)	
Q9. Is there any other type of content or activity you would have preferred seeing in the Programming or AI Section of the camp? (Free Response)	X
Q10. Is there any other feedback that you would like to provide? (Free Response)	X

Follow-Up Survey

The follow-up survey was also created using Qualtrics by the EQuIPD grant and sent to the same 28 students by the Upward Bound grant director on January 4, 2024, 5 months after the camps conclusion, in order to gauge their perceived retention of the information and confident students were about the material they had learned. The goals of these questions are the following: acquire basic respondent information such as their grade level, gauge the student's interest on STEM topics, gauge the student's perception and experiences with remote learning, gauge the student's experiences with the software utilized during the curriculum, gauge the student's perceived utilization and confidence in understanding of the material, and student likes and dislikes concerning the curriculum [Tab. 3].

Table 3. Student Follow-Up Survey Questions by Category

Survey Question	**Student Information**	**Tool Accessibility**	**Content Efficacy/ Impact**	**Student Interest**	**Student Experience/ Preference**
Q1. What grade are you currently in?	X				
Q2. Before attending this camp, had you already participated in other camps/activities focused on technology-related topics (such as AI, coding, or robotics)?				X	
Q3. How familiar are you with remote learning (online schooling, Zoom, etc.)?		X			
Q4. Do you prefer learning remotely using online tools, traditional in-person teaching, or a combination of both?					X
Q5. In the course, you used nanoHub to access the python Jupyter Notebook. How was your experience accessing, saving notebooks, and interacting with nanoHub during the camp?		X			X

Q6. How was your experience using Jupyter Notebook during the camp (the coding tool used during the Programming section)?	X			X
Q7. Did you use nanoHub outside of the classroom to work on your chatbot or in general (other online tools on the platform)? [Select all that apply]	X		X	
Q8. Do you utilize new skills that you learned from AI and Programming in your everyday life or schoolwork (such as design/engineering/systems thinking)?		X	X	
Q9. Based on your experience, how confident are you in completing the following: (Likert with 8 different scenarios involving AI/Programming topics)		X		
Q10. What was your favorite topic or activity from the Programming or AI Sections of the camp? Why? (Free Response)				X
Q11. What differences would you have liked to see? What could have made the experience in these sections more enjoyable for you? (Free Response)				X

Interviews

Interviews were conducted by the EQuIPD grant over Zoom on January 16, 2024, with the instructor of the in-person AI Section instructor and the Upward Bound grant director, separately. The goals of these interviews were the following: understanding the barriers faced when preparing to instruct the curriculum, the preferred organization of curriculum materials and supplemental resources, how online and cloud-based tools effected both teacher and student experiences, the most effective and least effective aspects of the curriculum from the instructor perspective, and overall feedback on the experience. While these questions were slightly different, most were similar, and can be seen in the table below [Tab. 4].

Table 4. Interview Questions Categorized by Respondent

AI Section Instructor	Grant Director
Q1. How did you prepare for teaching each day's curriculum? What changes would you have made to your preparations if you had more time?	**Q1.** How was the preparation of students and instructors facilitated each day? What changes would you make to their overall preparation for future iterations of the camp and why?
Q2. How do you prefer teaching resources and content to be formatted? For instance, how the content is sent or received, accessed, and organized in the files. **Q2a.** What did you like about the teacher guides provided? Why? **Q2b.** What did you dislike about the teacher guides provided? Why?	
Q3. In what ways do you believe the online tools influenced student's experience or learning?	
Q4. What do you believe was the most impactful part of the curriculum for students? **Q4a.** Why do you believe this section was effective?	
Q5. What do you believe was the most engaging part of the curriculum for students? What grabbed their interest the most? Why?	
Q6. What do you believe was the most challenging or difficult part of the curriculum for the students?	
Q7. What changes in the curriculum would you like to see if you were to participate in its instruction or facilitation again? **Q7a.** Are there additional features, other than the curriculum, you would like to see change?	

Data Analysis and Discussion

In the following section, the sub-sections indicated by the diagram below will address the listed research questions with results gathered from the surveys and interviews described previously [Fig. 6].

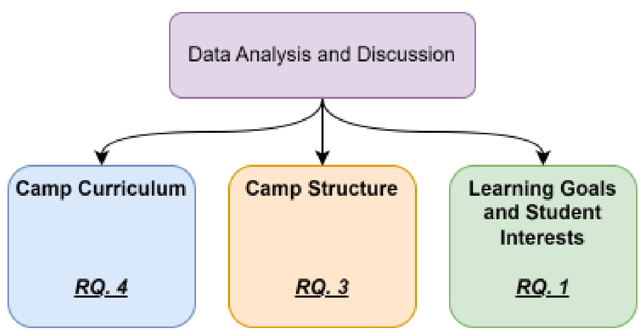


Figure 6. Data Analysis and Discussion Sub-Sections and Research Questions

Camp Curriculum

This section aims to answer the following research question:

> **RQ4.** What parts of the developed curriculum were found adequate by students, and which areas need to be improved?

In the post-camp survey, given to students directly after the conclusion of the camp, students responded to questions aimed at gauging their knowledge, experience, and interest related to the topics discussed in the curriculum (13 total responses) [Tab. 2]. In order to contextualize their different experiences with each section and develop a better generalization of students' prior knowledge on AI and programming topics, students were asked about their exposure to these topics prior to the camp [Fig. 7].

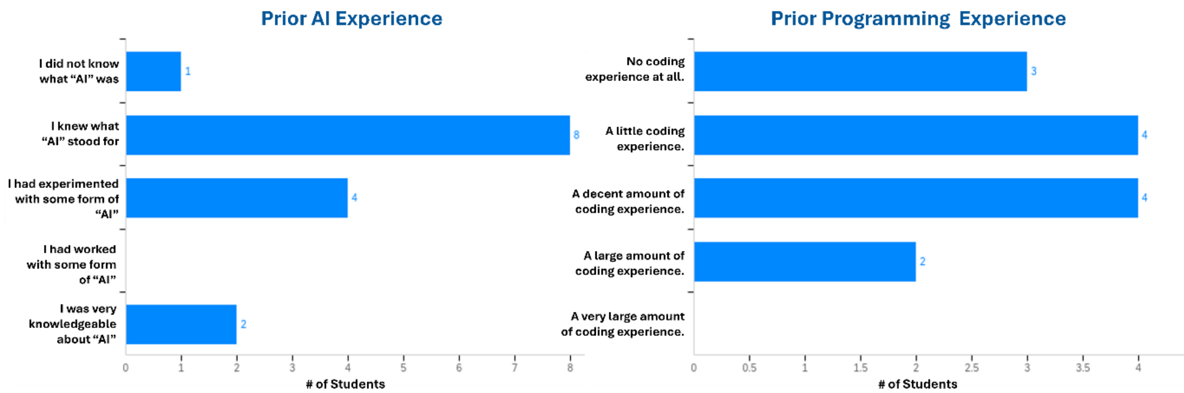


Figure 7. Student Experience with AI and Programming Prior to Camp – Q3 (Post-Camp Survey) [18]

The left side of the figure shows student's reported experience with AI, while the right side shows their experience with coding (students were allowed to select multiple answers). While 3 of the 13 students reported no experience with coding, only 1 of the students reported no prior knowledge of AI [Fig. 7]. These results are consistent with the reported difficulty of the programing section compared to the AI section, as the surveys and interview indicated students had more difficulty with coding than understanding AI concepts. In contrast to this, students with experience in coding reported having more opportunities to work with it hands on than students with AI experience, in addition to no students reporting that they have worked with any form of AI prior to this camp. This highlights the gap in AI "hands-on" experience opportunities afflicting students that the curriculum's end goal specifically addresses.

In response to Q4 from the post-camp survey, students indicated that they preferred both the instruction and content of the AI section compared to the programming section as mean average [Fig. 8].

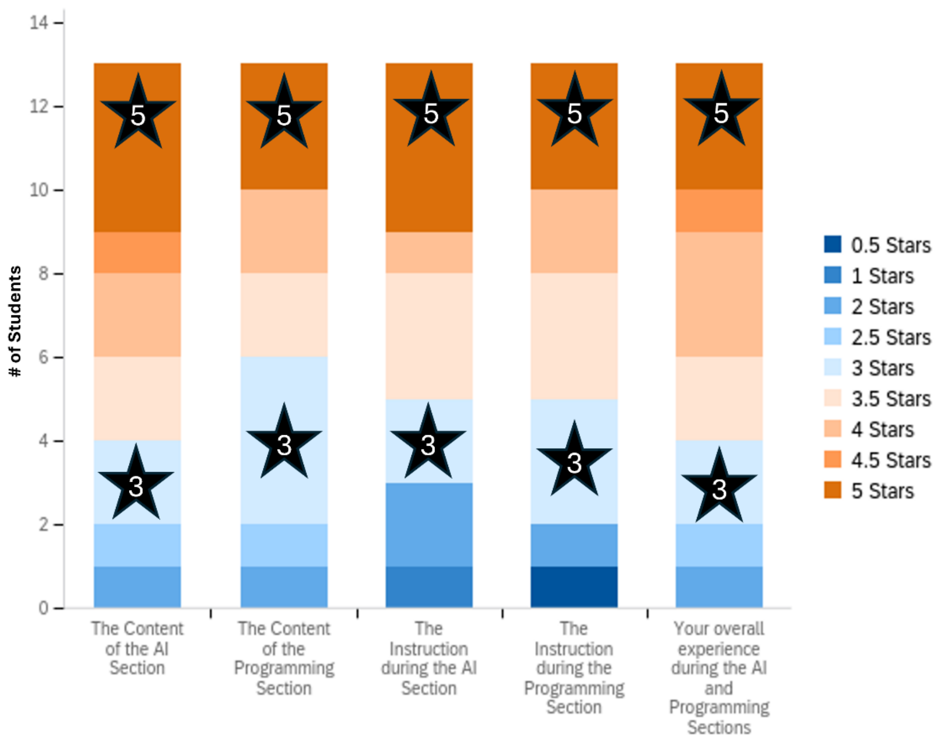


Figure 8. Student Ratings on Content and Instruction – Q4 (Post-Camp Survey) [18]

However, analyzing the median scores, most sections received a rating of 3.5 stars, outside of the AI content and overall experience receiving a median of 4 stars. This disparity could be related to either the method of instruction, style or medium of instruction, prior knowledge of the content, or pacing or difficulty of the content which aims to be narrowed down by open-ended responses from students and the faculty interviews.

During the interviews, both the AI instructor and grant director (who instructed two of the sections when the instructor was absent), the most impactful and engaging portions of the curriculum were discussed in Q4 and Q5 [Table 4]. The grant director stated the storyline activity (conversation mapping) was the most engaging, as well as the chatbot presentations for those who were able to complete them; as students completed a deliverable, they were excited and had a sense of accomplishment. Furthermore, the grant director stated that when activities had something for every individual to do, such as the conversation mapping and the comic-strip "Medici Effect" activity (in the AI ethics section), it was much more engaging. The AI instructor believed that all "hands-on" parts of the curriculum were the most engaging, and that it benefited students much more than traditional lecturing. He believed that elicit activities such as figuring out what AI was for themselves and experimenting with chatbots on their own was much more engaging than simply lecturing about what AI exactly is. The most impactful part of the curriculum, according to the AI instructor, was seeing the chatbot function at the end and seeing the “fruits of their work”.

While the chatbot function at the end of the programming section was an impactful aspect of the curriculum as a whole, this section’s content lacked the group projects and in-person interaction that instructors believed was crucial to the student’s enjoyment. During the programming section, from remote instructor observations, some more experienced students did help their neighboring peers with coding issues, but activities did not require collaborative coding, unlike the small group projects and discussions in the AI section many students enjoyed.

In open-ended survey questions students also indicated that activities with more creative aspects and design elements were more interesting, as well as some students requesting more interactivity in the programming section and “more complicated code”. However, some students expressed that the programming section needed to be “easier to understand” and that they needed “more time in class”. A solution for this may be to include optional advanced portions to deliverables for students with more experience or looking to challenge themselves.

Camp Structure

This section aims to analyze student and facilitator experiences with the hybrid-remote structure as well as further address the following research question:

> **RQ3.** How can we use cloud-based interactive tools to expand student access and equity and serve underrepresented youth to provide confidence to pursue data science careers through relevant industry knowledge?

In addition to analyzing student preferences concerning the camp curriculum, survey questions also had the goal of determining the perceived effectiveness and enjoyment of different learning styles and tools. In the follow-up survey, sent to students 5 months after the camp’s conclusion, students were asked about their familiarity and preference concerning online tools and remote learning [Fig. 9].

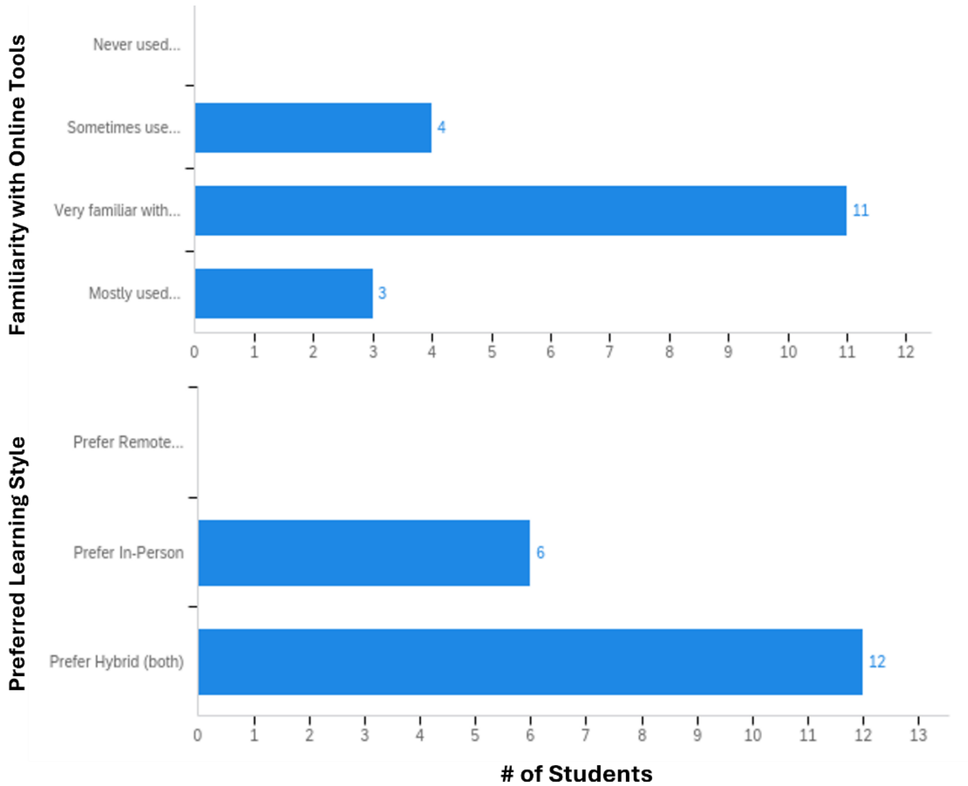


Figure 9. Student Familiarity and Preference with Online Learning – Q3,4 (Follow-Up Survey) [18]

While many students were very familiar with online learning tools (14 out of 18 total respondents), and all students have utilized them prior, none of the students preferred a strictly remote experience. While not reflected in the instruction rating of the programming section seen above, the majority of student responses in this survey favor hybrid-remote instruction compared to strictly in-person (12 out of 18 total respondents) [Fig. 8, 9]. Additionally, when "breaking-out" the question by grade level, all seven grade 10 students that responded preferred a hybrid-remote structure, while it was preferred by 5 out of the 11 respondents from grade 11 and 12 [19]. However, when breaking-out the ratings of the programming section instruction in a similar manner, there is little discrepancy between ratings of the various grade levels [19]. This may indicate that students would prefer different online tools or more in-person facilitation for this section.

When looking at student interactions with these specific online tools from the programming section, most students (10 out of 18 respondents) described their experience as either good or excellent, with the students having a slightly worse average experience with Jupyter Notebook compared to nanoHUB [Fig. 10].

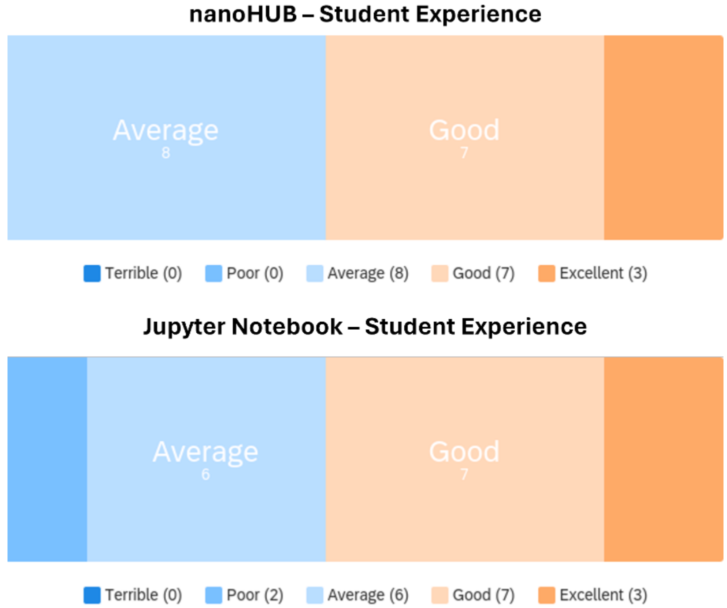


Figure 10. Student Experience with Online Tools from Programming Section – Q5,6 (Follow-Up Survey) [18]

Given these results, it implies student sentiment is not entirely negative towards online tools, but most likely a pitfall of using more complex online tools without more supportive in-person facilitation, further corroborated by discussion of the programming section during the interview.

When discussing the most challenging parts of the curriculum (Q7) with the grant director, they discussed the need for better in-person facilitation during the programming section, so students were able to receive help with technology related issues [Tab. 4]. Many challenges resulted from the shortcoming of tools and preparation, rather than the curriculum alone, however it could have accentuated these barriers. Overall, the grant director believes this resulted in the programming section being a more difficult spot for students in the curriculum. Similarly, the AI instructor believes that the time constraint in combination with the difficult nature of learning programming became the most challenging part of the curriculum. This was made more difficult due to many students never being exposed to programming before this curriculum and then having to create their own program within six weeks.

In addition to being introduced to complex concepts with inadequate in-person assistance, the grant director stated (Q3) that online tools sometimes created further issues due to the complications of where to find files and getting acquainted with the software, some students found themselves disengaged from the learning process [Tab. 4]. This was exacerbated as the in-person facilitator for the AI section was similarly unfamiliar with the software and had difficulty explaining how to navigate these new tools. Students shared this same concern through the open-ended survey questions as they stated “it was hard getting help” in the programming section and that it would "be more enjoyable if the teachers were in-person" [18]. It also took additional work to catch students up if they missed any days during the six-week camp, as they also had to become familiar with aspects of the online tools they missed, making it easy for students to "get lost and stay lost". In contrast, the AI instructor said that the novelty of the online tool (referring to nanoHub) made students more interested, and that he would most likely explore other applications on the tool in the future.

Learning Goals and Student Interests

This section aims to analyze student interest in the concepts and tools featured in the curriculum, as well as further address the following research question:

> **RQ1.** How can we utilize an Inquiry-Based Pedagogical Model to encourage future learning and retainment of information?

The last goal of the curriculum this section aims to analyze is the learning outcomes of students and whether they are interested in pursuing other AI and programming related opportunities. While students rated the AI section curriculum and instruction higher than the programming on average, responses also indicated that more students are interested in learning more about programming than AI [Fig. 11].

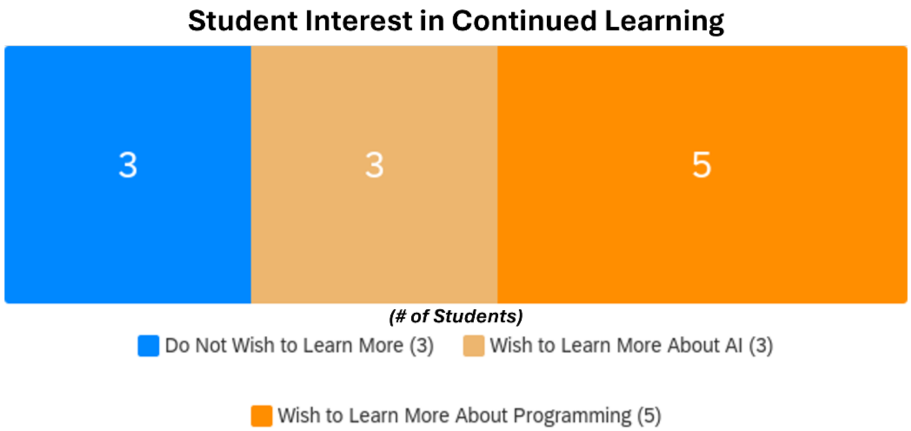


Figure 11. Student Interest in Continued Learning by Topic – Q8 (Post-Camp Survey) [18]

This disparity indicates that a reorganization of the content and structure could improve the experience of students and that disinterest in the topic is most likely not the cause of lower ratings.

In the follow-up survey, students were asked if they utilized nanoHUB outside of the classroom or explored additional tools (other than Jupyter Notebook) on the website [Fig. 12].

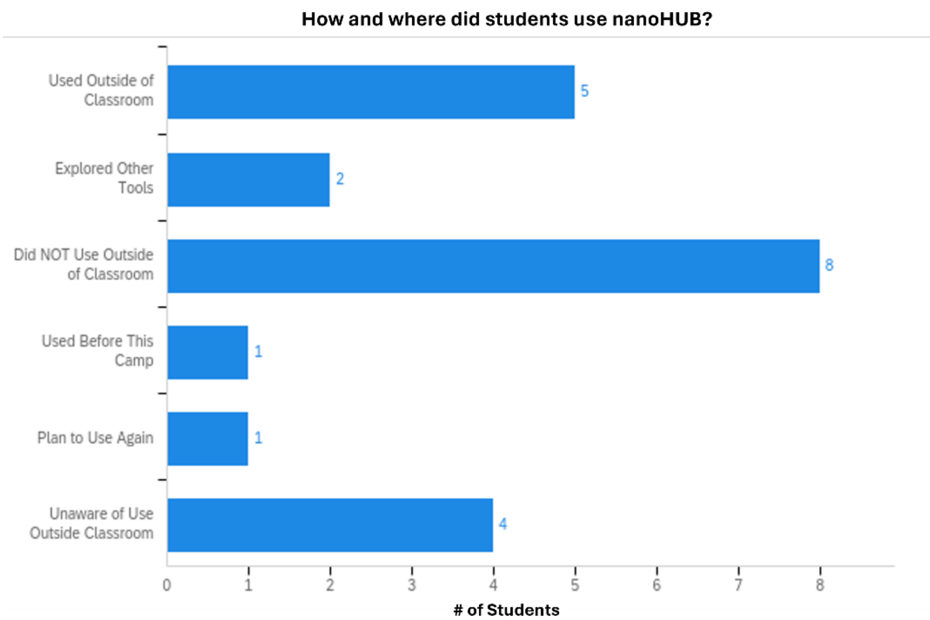
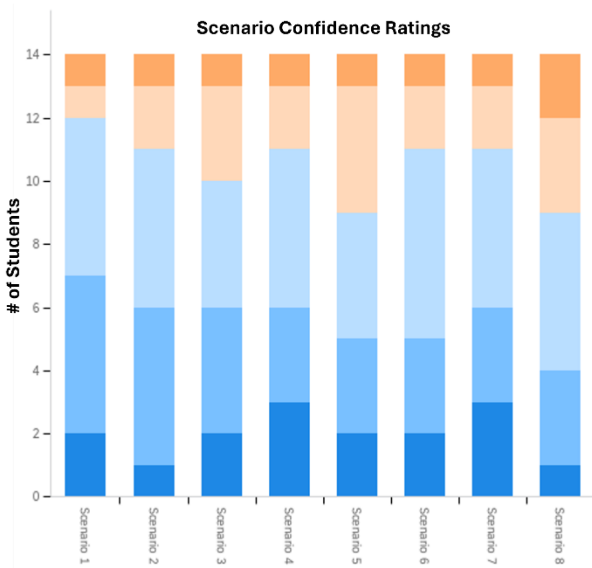


Figure 12. Student use of nanoHub Outside the Classroom – Q7 (Follow-Up Survey) [18]

Many of the students who responded were either unaware they were able to use the software outside of the classroom or did not attempt to do so. If this were made clearer to students, or practice work was recommended, it could improve student interest as well as remedy the need for extra time and the lack of advanced topics they could explore at their own pace.

At the end of the camp, students reported overall moderate confidence in the skills learned based on the given scenarios listed below [Fig. 13].



Scenario	
1	Working on a similar coding project using Jupyter Notebook
2	Discussing Artificial Intelligence and its different applications
3	Helping another student with their Python code
4	Explaining the basic parts of rules-based chatbots
5	Discussing the ethical concerns of Artificial Intelligence
6	Creating your own projects/programs using NanoHub and/or Jupyter Notebook
7	Discussing the different parts of "systems thinking" and how to use it for problem solving.
8	Creating a process map or flow chart to describe a given scenario.

Not confident Slightly confident Moderately confident Very confident Extremely confident

Figure 13. Student Confidence Ratings for Given Content-Related Scenarios – Q9 (Follow-Up Survey) [18]

When adding together students that are not confident and only "slightly confident," the scenarios students were least confident in completing were helping other students with their Python code, explaining the parts of a rules-based chatbot, and discussing systems thinking and how to use it for problem solving. Students were most confident that they could discuss the ethical concerns of AI, create their own project in Jupyter Notebook and/or nanoHUB, and create a process map or flow chart describing a given scenario.

Future Work

Based on the feedback from the students and in-person faculty, the main features that need to be addressed in future iterations of the camp are: better deliverable integration into the programming section activities, more interactivity and collaboration within the coding portions of the curriculum, and additional training and support for in-person facilitators.

As indicated by student responses and facilitator interviews, it is important that a story is created using Python, and that that story should encapsulate both the AI and Programming sections. While the chatbot told a story that kept students interested, it was not entirely present in earlier portions of the programming curriculum. For future iterations of the programming section, introducing topics such as data types and data structures in terms of the chatbot, rather than those chatbot terms coming after, would help create a more robust mental model for students to build from. In addition to this, the grant director has recommended including the chatbot in the final symposium at the end of the camp where groups can choose between a variety of projects.

Similarly, curriculum alterations should also focus on interactive assignments where students can work towards a common goal in groups and share their creations. Many of the students preferred the group projects and final deliverables; having more "end-products" will improve student confidence and engagement.

Apart from curriculum shortcomings, future iterations of the program will mostly avoid time constraints for in-person facilitators as material will be iteratively built upon rather than created from the ground-up. Additionally, given expressed preferences for a combination of in-person and virtual learning opportunities, it would be ideal for a member of the EQuIPD grant to be present to assist with instruction and facilitation during the programming section.

This following summer, EQuIPD plans to work with MathWorks and Upward Bound at the Miami Dade College Homestead Campus to create a MATLAB variation of this AI curriculum focused on sports and entertainment. This program is in the planning stages and will include time for in-person facilitator/instructor training.

Contribution to the Field

With the growing importance of AI, increasing the accessibility of these tools and understanding how to make learning them more engaging is an essential part of combating the bias that comes with a lack of representation in the field. This research contributes by providing insight into what constitutes an effective versus ineffective approach to providing STEM learning opportunities to URM students in hopes of improving future diversity in the field of AI. Using the results and implications of this study, we can refine future curriculum development and delivery to improve its effectiveness at keeping students engaged and encouraging them to seek additional opportunities.

Conclusions

This hybrid-remote summer camp curriculum developed by the Engaged Quality through Instruction Professional Development (EQuIPD) grant, taking place at the Miami Dade College Homestead Campus in conjunction with Upward Bound/UNITE introduced 28 URM students to the concepts of Programming and AI through an inquiry-based model. This model was an essential piece of creating a compelling storyline that was both engaging for students and easy for instructors to follow in the classroom. Furthermore, the introduction of thought processes such as systems thinking and engineering design are a perfect fit for this model as students can create their own definitions and mental models with systems thinking, and eventually their own creations through the iterative process of engineering design. The formation of these mental models can be reinforced through introducing students to different perspectives, such as relating the terms and concepts of AI to the art and language of Programming, so students form lasting relationships with these ideas. While the hybrid-remote structure and cloud tools are useful for reaching students with technology-accessibility barriers, the initial learning curve will be overcome in future iterations of this curriculum.

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