Youth Experiences with Authentically Embedded Computer Science in Sports

Authentically Embedded Computer Science in Sports

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Research on bridging sports and computer science education tends to center computing as primary, and sports as secondary. In contrast, this project aims to center sports as primary while introducing technology and computing as avenues to engage with sports more deeply. We collaborated with basketball coaches to design and implement campamento:bit, a summer program with a basketball team of Latinx students in Puerto Rico. This program integrated computing artifacts in a traditional basketball camp. We present insights from our experience testing this program with 11 participants over 5 days. We present select case studies of participant experiences and developing understandings using a qualitative-methods approach. These analyses present different shifts in athletes' perceptions of computing and instantiated students' interests in future possibilities involving computing. Furthermore, the analyses suggest strategies for organizing such technology-integrated experiences for youth in sports contexts.

CCS CONCEPTS • Applied Computing • Human-Centered Computing

Additional Keywords and Phrases: Cultural sustaining desings, Computer Science Education, Design Based Research, LatinX Communities

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1 INTRODUCTION

Computer science (CS) continues to see heavy underrepresentation from women and gender minorities, LatinX, Black, and Indigenous communities [4, 6]. Several factors contribute to this reality including a lack of local role models and out-of-school opportunities for experiencing CS, limited in-school opportunities, monolithic curricula, and toxic work and learning environments [4,6,15]. Sports participation, on the other hand, is a central aspect of adolescence for many youths of the same groups [18]. This is especially true in Puerto Rico where the physical toll of year-round sports participation

recently garnered attention from several mainland US newspapers while garnering advocacy for instituting a variety of restrictions on youth participation in sports [5]. In contrast to restricting participation in sports, this paper leverages youth interest in sports as an opportunity to highlight connections between athletics and CS. This is particularly relevant given the recent identification of the limited CS education opportunities available throughout Puerto Rico [17]. In response to this, we look at how to develop sports-related experiences that allow youth to gain awareness and a sense of agency around computing tools and methods, while centering their interest in imagining richer sports experiences. Although previous computing education work has investigated leveraging sports as a space for learning [3], our work uniquely focuses on team sports and integrating coaches in the co-design process. We believe the benefits of this innovative design are twofold. First, it honors students' identities and roles in an established community of practice [12]. Second, it includes intentional coordination with coaches who serve as strong relational resources in student-athletes' lives. Importantly, we strive to create experiences that are productive in expanding learners' athletic and personal identities, rather than replacing prior identities to center technology. Our research questions are the following:

RQ1: How does a basketball program that authentically embeds computer science artifacts (AI-technologies and physical computing) provide short-term shifts in students' perceptions of computer science?

RQ2: How do participants experience this program in terms of identity, goals, and learning?

To answer these questions, we developed a learning experience that centered around youth interest in basketball. Broadly speaking, this paper presents ideas about designing authentic sports-focused learning environments that also support computer science education. It highlights possible outcomes from such programs and puts into perspective ways for measuring their impact. This paper serves as a point of reference for the types of student engagement that can be achieved with similar designs and tools.

2 RELATED WORK

The current project builds on prior research in culturally sustaining computing which has demonstrated meaningful ways to engage minorized youth in computing experiences that elevate and further inform their understanding of their own ethnic practices [10]. Sometimes termed ethnocomputing, these projects recognize different youth identities as assets that prepare them to engage with computer science concepts. Nasir et al.'s [11,12] work on practice-linked identities show how material, relational, and ideological resources available in different settings (including sports) can support development of learners' identities and goals in practices. Nasir [11] leans on Wenger et al.'s [16] description of the construction of identities in communities of practice as being composed of engagement, alignment, and imagination. This line of work also frames computing as a tool that might be used to contribute to or proliferate existing cultural practices. This paper similarly positions a frequently racialized sports identity, as an asset that can both benefit from computer science, and contribute to youth understanding and interest in CS. Namely, we explore ways that computing can help youth improve their athletic performance, and ways that athletics can be a generative and fulfilling space to learn about CS [7]. In this way, we are leveraging ideas from culturally sustaining computing within a sports culture. Unique to our context is supporting students' ability to express themselves through participation in sports, and the social component – belonging to a team and working towards shared goals.

Collectively, this prior work and others, suggests that sports can be a generative space for engaging youth in meaningful learning with and about technology. However, in contrast to prior research, the current study is more explicitly situated in a sports context. Namely, youth are primarily attending the program to improve and practice basketball. Hence, whereas prior work has successfully layered athletics into existing educational settings, fewer studies have explored effectively and authentically layering computer science into a sports context with organized teams and experienced coaches. We pay

attention to identities as formed and specified through how learners describe themselves, learning as shifts in the use of artifacts, and engagement as intensity in the activity at hand [11]. We proceed by describing the study in the following sections.

3 STUDY DESIGNS

Campamento:bit (bit for basketball, information, and technology) is a program that integrates wearables and data science into team sports [7]. Program activities were co-designed and co-led by a social worker, two coaches, and a PhD student. The program was conducted as a five-day summer program that incorporated computing in a basketball camp. The program involved a high school basketball team composed of 11 students using computing tools to engage in traditional basketball activities. Participants identified as males (he/him). The program took place at the team's basketball court. The program met for 2 hours each day for a total of 10 hours.

We employed a combination of commercial and custom-built tools to assist players with their athletic goals, help participants decipher how different tools work, demonstrate limitations with current tools, and show players how to make their own tools when current tools do not serve their needs. Commercial tools included Homecourt.ai, SIQ basketball, and more. Homecourt.ai is an app that uses computer vision to track players' performance, and provides a combination of drills, workouts, and detailed real time data on players' performance. The SIQ basketball contains sensors that track shots and shot metrics. We used micro: bits for custom programs and wearables.

3.1 Camp Activities

The program followed the structure of a traditional basketball camp where players practice each component of the game: shooting, passing, dribbling, and defense. Each day included conditioning drills, skill development activities, and full court scrimmages. Computing tools were embedded into different activities across the five days of the program. To support athletes' sensemaking around how technology influences activities, we first facilitated activities with no computing tools, and then with computing tools. In addition to the basketball activities, each day included a design activity and various assessments. On the final day participants competed in a technology-enabled all-star competition.

The computing tools were an opportunity to test different sports wearables and subsequently support asking questions, data exploration, leading discussions, and designing new artifacts. These different practices were realized across the set of basketball drills and assessments. To demonstrate how we make custom programs, we programmed micro:bits for activities in both wearables and technology-enhanced drills. While we will not describe each of the camp's activities in detail, we will use the paragraphs that follow to highlight a few that were particularly resonant to participants: decision making drills, data discussions, and question asking.

Decision making drills challenges players to process information fast and make the right decisions. For example, one drill asked players to take different actions based on a randomly generated number and within a small-time frame. Following our comparison design, players start by positioning in dribbling form with a basketball and based on the number facilitators shouted out they had to act. Numbers had the following action associated with them. 1 do crossover, 2 do jab-step, 3 dribble between the legs, if higher than 3 and even do a bounced pass, if higher than 3 and odd do a pocket pass.

From the second day onwards, we would select players to explain and interpret the results from SIQ basketball and Homecourt.ai in front of the team. They would go through different statistics the apps contain and provide their interpretation to their teammates. This exercise asked students to think through what they were reading and explain it to their teammates. Facilitators assisted players through these exercises.

Players were encouraged to ask questions throughout the camp about the activities and tools. After having them use a specific tool, we asked them to question if it was serving their specific needs, and to further consider alternatives to specifically improve their athletic performance. Additionally, after each session of collecting data with tools, we asked players questions about the data collected such as: "how many attempts did you think the team took?," and "How many of those did you think the team made?." Together, these activities, tools, and discursive practices provided students with a glimpse of computer science and raised awareness and interest in designing novel and relevant sports-wearables.

4 DATA COLLECTION AND ANALYSIS

4.1 Overview

Mediating processes in design-based research [13] provide a way to assess design components with intended outcomes. Our design components are artifacts, activities, and discursive practices. Our intended outcomes are shifts in perceptions about CS, and participants' experiences with the CS component of the program. Mediating processes involve the data we collected through field notes, videos, and surveys, as well as the participants' designs and daily journals. This data allowed us to get breadth and depth of evidence to support links between learning, identity, and goals. The survey responses focus on students' feedback on the camp structure and activities, their overall perceptions and awareness of computer science as it relates to sports, and elements of their goals and identities. Design sketches allow for examining how students made connections and instantiated learning by imagining different futures with technology. Video recordings and field observations support focused analyses into participant interactions and experiences with the activities, tools, and discursive practices used. Through an iterative process, notes were analyzed to identify overall themes in the camp. As we looked across those themes, we found that three out of eleven participants provide diverse examples of breadth in thinking about ways that this type of learning experience might influence youth athlete perceptions and interest in computing.

5 FINDINGS

We follow the same general structure in constructing each case study. First, we introduce students by discussing their identities and goals at that moment as reported through the surveys and the coaches' informal interviews. Next, we present a few pertinent interactions with the different components of the design. We conclude by presenting one or more of their design ideas. We organize these three sections under the heads of identity and goals, engagement and interaction with the program, and design [11].

5.1 Marco

Identity and Goals – Marco was 17 years old and his favorite things about basketball were having a winning attitude and movement. He was also a passionate fan of playing and watching basketball. Marco was highly disciplined when it came to school and basketball. When we first met, he and his father shared their basketball routine for the summer. Their routine started at 4:30am with 3.5 hours of training at a local basketball court. His father, Alberto, video recorded Marco's shooting sessions on his phone, and then manually counted the number of attempts, misses, and makes on a piece of paper. Marco reported using his cellphone to watch a lot of basketball clips and drills on YouTube. For instance, he was an avid fan of "Deep Game", a channel that helps people become intelligent basketball players by improving fundamentals and agility. Marco said that he had no previous experience with computing. His favorite classes were math and science. His long-term goals were to play professional basketball and study engineering in college.

Engagement and Interaction with the Program – During the camp, Marco showed genuine interest in learning about the different technologies. For example, he asked how the micro:bit could approximate distance during a 1-on-1 drill. He was attentive during explanations of how tools worked and often sat near the coaches as we provided explanations. He found conditioning drills to be intense, and decision-making drills to be particularly important and essential.

A favorite technology for Marco was the SIQ basketball. Going back to our initial interaction with him and his father, they were collecting shooting data by hand. When Marco found out the SIQ basketballs could track all data with the ball and app, he instantly wanted to learn more so that he could purchase his own ball. He found having specific data on spin rate, consistency, and release angle to be extremely important. For example, on Wednesday's journal entry he wrote: "I liked all the practice, the reason I liked it was because intelligent tools were applied that have little error rate; they are accurate."

Design – Marco's design during camp was a sketch of electronic glasses that would give a random number, directions, and cloud his vision (like drunk glasses) to improve his decision-making abilities on the court. His design drew from a combination of artifacts he used in the camp as well as his specific goals of becoming an intelligent point guard.

Through the program, we observed Marco's shift from trying to find resources to improve his athletic performance to realizing his ability to make tools that could serve his needs. Initially he used paper and pen to track shooting performance and looked up drills on YouTube. He also thought of computer scientists as just individuals working with computers. By the end of the camp, he wrote that computer scientists can manipulate programs and make them do whatever they want.

Marco's journal entries reflected his overall positive experience with the camp and computing. His reasons for really liking computing per journal entries were that having computing allows for precise measurements, isolation of data, and improving specific aspects of the game more objectively. At the end of the program, he asked to borrow a micro:bit to practice decision making drills on his own because he found them helpful. He also purchased two SIQ basketballs and asked to continue training with the camp leads. He has continued to collaborate with our team and is developing expertise with making physical computing artifacts with the understanding that it can support his athletic performance.

5.2 Zach

Identity and Goals - Zach was 16 years old and liked basketball because of physical activity and team chemistry. He reported playing basketball since he was a child and liked watching basketball games. All his friends also played basketball. Because of his passion for basketball, he was excited to see how our technologies could be applied to the game. Initially he reported that computing could be an interesting profession if sports were related to it. His favorite class was physical education. His long-term goal was to play professional basketball.

Engagement and Interaction with the Program - During the camp, Zach was attentive all the time we were setting up technology and giving instructions. At the same time, Zach perceived all the technologies as expensive, so he was initially reluctant to touch the micro:bits and Spalding Smart Shot. He tended to be careful passing iPads and SIQ basketballs around. He did not ask specifics of how artifacts worked but made comments expressing how impressive it is that sensors could collect diverse types of data. Although initially reluctant, Zach liked the Spalding Smart Shot because it provides useful feedback on shooting arcs.

Decision making drills helped Zach self-reflect on aspects of his game that needed work. He noted in his journal that he needs to make better decisions during game situations. Zach's journal notes, "I learned decision-making and what it is to work while you think, the drills helped us as a team to work 2 against 1 and it benefits us when we are in the race." The drills he referred to were focused on individual skill development and not on team dynamics. Even so, Zach connected an individually oriented drill to an actual team-based in-game situation (i.e., "we are in the race"). "We are in the race" means

when a team is on a fast break and can score points fast. While using Homecourt.ai his focus was on completing workouts and improving his scores.

Design - Zach designed a wrist band and circle sensor that would go by one's heart. Combined with a cellphone app they would track health data. When asked why he would like to make this design he reported that it would be exciting to make an artifact that younger children could use to improve their health and performance. He made outside connections to his interests since we did not talk about health data during the camp. He was thinking of applications to help other people's health. His design represented his interest in the social aspects of sports. Zach also added more elements to his design than his peers. He thought more about the pipeline and distinctive features of the design (app, wearable, data collected).

5.3 Alen

Identity and Goals - Alen was 17 years old and liked to play basketball with his friends. His favorite thing about sports was the adrenaline of the game. He reported his role as a team leader and liked to keep the team under control during games. He also enjoyed assisting teammates through plays and difficult drills. He found technology boring and mostly used his phone to communicate with friends and social media. Alen did not think programming was useful for him and described programming as hard. The traditional basketball component of the camp helped Alen stay engaged during the camp.

Engagement and Interaction - His behavior during camp can be described as a mixed engagement. Alen showed little interest in most drills involving computing artifacts, but he was highly engaged with the most physically challenging and cometitve drills. He also seemed to enjoy assisting peers with decision making drills. Alen seemed distracted during explanations of technology. Even so, he always engaged in traditional basketball drills and helped others during decision making drills. Alen also enjoyed the camp drills for improving his athletic performance. Throughout most of his journal entries Alen focused on the basketball aspects of that day's activities. For instance, his Aug 26th entry notes "Thursday: good conditioning and coordination on defense". He seldom mentioned the technology, except for enjoying the Homecourt.ai dribbling drills. While using Homecourt.ai, his focus was on having the best times or trying to be the fastest.

Design - His camp design was a case that would protect the micro: bit and tiny computers from damage given that we are in a basketball court and "accidents happen".

6 DISCUSSION

We see a couple of important implications from the case studies. First, they demonstrate that sports can be a space to engage in CS experiences and can serve as a possible starting point by centering practice-linked identities. Second, as we think through student experiences in relation to Nasir's model of goals, learning, and identity [11], we see that the intertwining of youth identity, learning, and goals can influence one another in dramatically diverse ways. Some might completely avoid the learning aspects related to computing tech, while others might not see much connection or changes in their goals, in the short term. Nonetheless, it is important to consider all these dimensions when thinking about the effectiveness of these experiences.

6.1 Authentically embedding CS in Sports by building on practice-linked identities

Looking across the three case studies, we see that participants were consistently drawn to the material resources of computational tools that we provided. For instance, Marco's interest in the SIQ basketball led to him purchasing one for himself. Many of the other technologies were similarly received and recognized for their clear connection to athletic performance. Importantly, students did report having heard of computing for basketball through social media platforms

and YouTube videos. For example, Marco mentioned watching videos of Chris Paul and Stephen Curry wearing sensors and performing reaction drills on YouTube. This program, however, provided direct interactions with artifacts that were specific to basketball and were brought into the local youth basketball context. Initially, these technologies seemed inaccessible, but this program provided access and awareness about the availability and affordability of some of the tools.

Access to technological tools is also connected to ideational resources. Participants were not only made aware of the availability of these types of tools, but they also engaged in the process of ideating new sports wearables, and the possibility of designing sports wearables as a possible future. To this point, Marco and Zach's continued participation in designing sports-related wearables after the conclusion of the program suggests that this experience influenced their interests in exploring the computer science design space. For other students, while they did not elect to go deeper in the design space, they still participated in, and learned about possible futures as designers of sports technologies. Even in the case of Alen, who demonstrated mixed engagement, there were clear instances where having participated in the practices of testing and critiquing technologies provided him with a tractable place to think about designing or enhancing sports technologies. Additionally, the discursive practices of the camp leads, and getting students involved in discussions around the data and its implications also served as important ideational resources.

Finally, the camp participants, camp leads, and family members all served as relational resources within this experience. Alen's case study highlights ways that he encouraged his teammates to continue to engage with the different decision-making drills. This type of interaction is an example of Alen's leadership, but also points to the general camaraderie that exists among the team. Zach similarly shared that all his friends play basketball, and that community was a primary driver for his participation in sports. In sum, engaging in this type of activity as a team of similarly minded high school athletes contributed to how players experienced the program. At the same time, the camp leads, who represent individuals with proximity to the players, but who also recognize the potential benefits that technology can bring to basketball, were a crucial resource for the players. Marco and Zach's continued engagement with the research team after the conclusion of the program speaks to ways that these students were both comfortable with, and value, their relationships with the camp leads. Finally, we see the roles of family members explicitly shown in Marco's case studies. This familial involvement was observed among our participants as many parents watched the camp experience.

6.2 Identity, learning, and goals

We are also interested in thinking about what the three case studies tell us about interactions among student identities, goals, and learning. We see this framing as generative because it surfaces nuance in how students uniquely navigate among these three constructs to create an experience that resonates with them.

6.1.1. Identities and Goals

Alen, as gathered from self-reported data and discussions with coaches, is a basketball player first and foremost. He plays the point-guard position and is the team captain. His identity as a leader was reinforced throughout the camp as he sought to help team members complete drills. Related were his goals about helping the team collectively improve. Hence, we see Alen, on several occasions encouraging his teammates to continue persisting through challenging drills. On the other hand, Alen does little to engage with the computing tech learning aspect of the experience. He has an appreciation for technology, and what it can offer, but is not invested in designing new technology. Hence, for Alen it is primarily the alignment between his goals and identity that characterizes and supports his engagement with the program. We think this is important given that Alen was still invested in the basketball aspect of the camp, thus supporting our original goal of providing an experience centered around participants interest in basketball.

6.1.2. Goals and Learning

In contrast, Zach's case study points to an experience that is typified by clear goals and a desire to learn. As a basketball player, Zach did not carry the same level of determination as some of his peers. For him, he was principally driven by the social aspects of sports and was excited about elevating and supporting the team's well-being and performance. His journal entry around team decision making was a clear example of this. Broadly speaking, many of his goals were team oriented. Additionally, his attention to technology was largely fueled by a desire to learn more and was less oriented towards basketball. His final project, which was a circle-shaped health monitoring device for children, provides an indication of this, as his device is not at all basketball specific. Moreover, his designs were the most extensive of anyone in the program, suggesting that he was deeply invested in ideating these future possibilities with technology.

6.1.3. Identities, Goals, and Learning

Lastly, whereas Alen and Zach displayed more team-based, collective goals, Marco's goals and identity were more individually minded. He is deeply motivated to play basketball at the professional level and his behaviors are driven by this goal. He sees the connections between the opportunities to create custom sports wearables, and his goals, and is therefore invested in learning more about physical computing. He does not necessarily view himself as a computer scientist but grew to realize that CS people are not the only ones who can make computer programs and wearable technology. Marco's experience exemplifies all three aspects of the relationship between identity, goals, and learning, as we each interact with the other to support his growth as a scholar and as an athlete. Marco was initially drawn to the program because of his identity as a basketball player, and his goal to become a professional athlete. Upon realizing that computing could help support that goal, he embraced CS, and has expanded his perceptions of his own identity and future goals.

Looking across each participant's interactions with identities, goals, and learning, we see the value of recognizing perceptions, behaviors, and shifts within each one as extremely important for studying this type of learning environment. Furthermore, in conjunction with the framing around material, relational, and ideational resources, there needs to be intentionality in making sure that participants have access to each of these resources, as each participant is likely to navigate these types of learning environments in diverse ways

7 CONCLUSION

Campamento:bit explored a learning experience that is first and foremost centered around youth interest in basketball. In this paper, we described the program and how three participants with limited prior experience with computing engaged with the program. We saw each participant engaging with the program differently, but in ways that are closely tied to their identities, goals, and interest in learning. We also described how the material, ideational, and relational resources made available through campamento:bit supported each participant differently, while collectively providing a space for all of them to have a meaningful and fulfilling experience. To conclude we provide answers to both RQs. In relation to RQ1, this program provides short-term shifts in students' perceptions of CS by providing a learning experience composed of artifacts, activities, and discursive practices that explicitly support participants' identities and goals as basketball players. Thus, by pairing CS with a practice they are deeply invested in (i.e., basketball) perceptions about relevancy and difficulty of CS were demystified. In relation to RQ2, we find that participants' experiences with the design of this program are distinct and based on their individual identities and positionality within the team. Accordingly, this paper shares ideas about how to design authentic sports-focused learning environments that also support computer science education. Additionally, it highlights some of the possible outcomes that might emerge from such a program and puts into perspective ways for measuring its impact.

8 SELECTION AND PARTICIPATION OF CHILDREN

The selection process of children was through the coach. Camp leads discussed the project idea and explained the participation process to the head coach. Once the coach agreed to participate with his team, we facilitated release forms for image, video, and design sketches. During the first day of the program, camp leads explained to players, coaches, and parents that the data collected could be used for publications. Players and their parents provided written consent to participate in this project.

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