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Preliminary Insights from Exploring Engineering Learning Ecosystems of Black Youth

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Preliminary Insights from Exploring Engineering Learning Ecosystems of Black Youth

Introduction

Informal learning contexts provide immersive experiences which can promote engineering learning and fluency [1]. Some learning experiences are highly structured while others are less formal and ill-structured. These less structured informal activities at times offer very intriguing engineering learning contexts ripe with opportunities for youth to engage in engineering thinking and to develop useful engineering skills. In these settings, youth have the opportunities to construct their own learning and to engage in activities that interest them [1]. Access to structured informal engineering learning experiences differs based on race and socioeconomic status [2]. Therefore, we shift our attention to address informal sociocultural settings. Sociocultural informal contexts within Black communities provide opportunities for youth to develop engineering related skills in culturally familiar ('real-world') settings. In a previous study, Tolbert [3] found 15 sociocultural practices which enabled Black youth to develop engineering attributes. Additionally, these practices allowed for access to Community Cultural Wealth.

Background

It is important to understand the diverse ways that African American youth access the engineering pathway and develop relevant engineering skills. Understanding access to engineering is critical as researchers and practitioners address the underrepresentation of African Americans along engineering pathways. Some African American youth have exposure to STEM concepts and activities early in their lives, while other may have limited access to STEM education and decide to pursue engineering later in life (senior year in highschool). Historically, African American and other communities of color have not had that same access to the pre-college STEM education as White communities. Yet, members of these communities of color have contributed to technological innovations and STEM achievements.

Underrepresentation of minority communities in STEM fields is not an accurate representation of the contribution of these communities to the field of engineering. In fact, there is a history of innovation and engineering ingenuity and display of engineering attributes in the African American community [4]. The historical engineering contributions of African Americans provide evidence that in the Black community, there might be common knowledge or experiences that provide opportunities develop STEM skills, knowledge, and attributes. Therefore, it is also important to investigate the diverse ways the individuals in the African American community develop and practice engineering skills and knowledge. These experiences and opportunities are identified and characterized in this study as sociocultural experiences.

Sociocultural experiences occurs at "the intersection of one or more actors [participants] engaging in one or more activities [behaviors] at a particular time in a specific place [5]." The study described in this manuscript was designed to follow-up an investigation of the sociocultural experiences of African American youth that fostered the development of Engineer of 2020 attributes [3]. From participants self-reported interview data, 15 relevant sociocultural contexts emerged. In this follow-up study, the research team sought to visit selected settings,

observe the youth in the contexts and identify how the youth engaged in the settings and how from this engagement they may be developing engineering skills and attributes. This work was supported by an observational protocol borrowed from the anthropological tradition. Our process is detailed in the methods section of this publication.

The theoretical framework which is guiding the exploratory study is Community Cultural Wealth [6]. This work situates underrepresented minority cultural groups as having practices, assets and competencies as opposed to deficiencies when compared to White cultural norms. We also situate this work with respect to understanding how Black youth make meaning of their community experiences. This approach allows researchers to map how "Black people interpret, act upon, and produce material (e.g., art forms, tools) as well as social texts (e.g., interaction, identity, ideology, strategies for action; [6]).

Literature Discussion

Ecosystem-sociocultural environments

Over the past few decades racism and hierarchy have dominated the classroom which heavily advantaged White middle class students. On the other hand students of color (especially Black students) were assumed that they did not have the resources nor the capital to compete with their White counterparts. In addition, they are less likely to participate in structured activities such as extracurricular activities; which give students opportunities to learn critical life skills and engage with peers. US public schools maintain a double standard for students of color that both marginalize and oppress, while at the same time, retaining their potential to empower students toward success.

A critical race perspective and critique of social capital has revealed and allowed cultural capital within communities of color to be identified, valued, and named [6,7]. Students learn navigational capital which builds resilience and efficacy. They learn these skills from their families by storytelling, scenarios, family history, parables, and narratives. In addition to the familial structure, African American/Black students learn at the communal level [8] Community organizations (e.g. churches, social clubs, civic groups) provides students an environment where they are able to talk, relax, and learn about the causes of issues occuring in their communities. This enables them to have critical social capital to bring political consciousness and a sense of a collective racial and cultural identity. In addition, they learn while having fun. As a result, they bring the knowledge from their homes and communities into the classroom.

Engineering learning in Ecosystems-sociocultural Environments

Since math is the foundation to science, technology, and engineering; students of color need to overcome the hierarchical and racist practices so often embedded and traditionalized in mathematical learning environments. In math and engineering, there is a need for minorities to live biculturally in an environment that provides very little support and still is very conservative. To combat these forces, in addition to learning critical social capital, previous work [9] has shown that students also learn the skills and qualities needed to succeed in engineering from their homes. To begin, parents reinforce resilience and efficacy which allows students to navigate through the rigors of the classroom by teaching them code switching and redirecting their fears to keep them in school and in STEM [9]. Black engineering students have attributed their success

from their families' teachings of their ancestor's struggle to achieve an education and also giving them the support needed. In addition, reports from students suggests that they emulate their caregivers skills such as "thinking outside of the box" and learning math from either their fathers or father figures [9]. In watching their parents/guardians, they observe how their parents struggle which fuels their desire to succeed and make their families' struggles worth it by achieving their degrees and giving back to their communities [9].

Research Questions

The following research questions informed the design of this study.

1. How do Black youth develop engineering skills within diverse sociocultural informal contexts?
2. What does engineering learning look like in these informal contexts?

Additionally, these research questions helped to craft the observational protocol field note prompts introduced in the methods section.

Methods

In this follow-up ethnographic study, the researchers pilot an investigation of these participant reported experiences by visiting settings within which these practices are known to occur and by observing participants in situ. Using a critical ethnographic research approach, the research team sought to observe African American youth and families engaging in engineering practices in public spaces. This work is positioned as a critical ethnographic study because of the ultimate aim to advocate for the diverse ways that the African American communities engage in engineering learning in ways that challenge current cultural norms about who has access to engineering pathways and how members of URM and non-URM communities develop engineering attributes.

The data included observation of Black youth and families in some diverse building, designing, and creative environments. We used the critical ethnographic lens to narrow the scope of what behaviors to observe and using the anthropological method of participant observation. Using participant observation allowed an intimate space to make objective observations while engaging directly with the participants.

Due to the exploratory nature of this study, the first author made no contact with the observant and spent limited time (between 30 - 90 minutes) in each setting. The time spent in each setting was determined by the activity taking place at the time, presence of target populations in the setting, and researcher schedules. Our objective was to visit selected settings and develop preliminary objective insights into the ways that the youth and families engaged in the settings with each other, with artifacts in the environments, and with the environment itself. There were no interviews conducted since there wasn't a consent form. However, based on the findings of this work, we will secure human subjects research approval to observe and engage with the participants in the settings as well as conduct interviews to expand insight into the behaviors and practices we observed.

In a previous study, Tolbert [3] found that the participants experienced 15 sociocultural practices that helped to develop engineering attributes. In this follow-up study we sought to investigate

two of the 15 practices that would allow us to simply observe interactions without engaging and were in a public space. These two practices were: designing, building, and creating with family members, friends, and classmates; and parents providing resources to help their child(ren) engage in engineering experiences. We selected 4 sites to observe the youth and their families engage in these practices. These preliminary sites are not all "Black Spaces" but rather represent diverse settings where engineering related skills and knowledge may be exercised [10].

1. Build a Bear Workshop
2. Museum of African American History
3. Science Center
4. American Girl Retail Store

The observational protocol includes the identified observational settings, developed descriptions of what was witnessed, and particularly interesting and surprising occurrences. Field notation was guided by the following prompts:

- How do Black youth develop engineering skills within diverse sociocultural informal contexts?
- What does engineering learning look like in these informal contexts?
- How did the space allow kids to design/create?
- How did they interact with others while doing engineering?
- How they interact with parents and vice versa?

Research Reflections

In this section, we present a summary of the field notes from each of the preliminary sites as reflections. We share our initial insights and reflections related to the settings visited and the engagement of Black youth in the respective settings. These reflections will inform our discussion and future research directions.

Build a Bear Workshop

Build a Bear Workshop was selected as a site because of the opportunities it provides its customers to "Shop, Explore and Play at Build-A-Bear." We also believed that this site might provide opportunities to observe African-American youth engaged in design and creativity. The company targets its' focus on children by providing them with opportunities to design a personalized stuffed bear for a cost. The company is identified "As the leading company offering a hands-on, Make-Your-Own furry friend retail experience [11]" The Build a Bear Workshop is located in a suburb of Urban city.

Reflection

At Build a Bear Workshop (BBW), the youth are welcomed with bright lights colors and stuffed bears in the shelves. This site provided our team the opportunity to observe Black and non-Black youth in a design setting that purposely integrated a step-by-step product making assembly line that was organized by interactive stations. The process is detailed in this reflection. Once child is ready to begin the "build a bear" process, they must first identify which bear they will build at the "choose me" station. The youth had many design decisions to make during this activity. For example, they could select design aspects such as the sound the bear might make. This design

was had many aides including a monitor to facilitate the selection of the sounds. Additional support included the store associate, who would instruct the youth on how to complete certain tasks (i.e., how to place the selected audio equipment inside the stuffed animal). The children, who were observed, typically worked well with the associates. After stuffing the bear with the audio equipment and other material, the youth choose between to visit the fluff me station or dress me station. The "fluff me" station is one of the interactive stations and it allows the visitors to "bathe" their bears in a digital bath tub complete with sensor and virtual bubbles.

Parent and child interaction was varied. Some youth freely explored and built on their own. For example, a child asked a parent for their opinion and the parent responded "you know more than me." Other parents gave their children suggestions or responded in a helpful manner when asked for advice. Some parents assisted their children as they selected clothing and accessories for the stuffed bear. BBW was designed with children shorter stature in mind as the clothes and accessories were within their reach.

Design and creativity were present throughout the process. While fully engaging in engineering was quite limited, BBW seemed to provide enumerable opportunities for the children to practice making design decisions, use creativity, and engage with the technology at the interactive stations. Having a seemingly unlimited choice of options, the children can use their imagination to explore design alternatives (i.e., change the bear, outfit, sounds, and accessories). This is similar to the trial and error process in design. In addition, the layout of the stations creates an assembly line where each station is a phase to complete a finished product.

Charles H. Wright Museum of African American History

This site was selected because it is a culturally Black space that is open to the general public located in an urban center. We anticipated that we would have an increased likelihood of observing African-American youth that engage cultural capital and knowledge while applying engineering skills. The *Museum of African American History* was founded in 1965 and houses over 35,000 artifacts [12]. The Museum's mission is to "open minds and change lives through the exploration and celebration of African American history and culture." It has a permanent STEM exhibit titled "Inspiring Minds: African Americans in Science and Technology, a permanent exhibition focused on S.T.E.M. concepts for children" and they host workshops that encourage designing, building and creating. We observed an event in their Family Activity series. Participants designed their own Thanksgiving placemats. The museum is located near a downtown Urban City.

Reflection

The museum not only presents information and artifacts related to the history of African Americans, it also gives its visitors a chance to learn about the historical contributions of African-Americans to the STEM field via its the Innovation Center. At the Innovation Center, students can learn and be inspired by the achievements by interacting with the displays the center has. Just outside the center wall that gives children a visual of the faces of African Americans who paved the way in STEM. It told them who they were and how their innovations changed the world. Unfortunately, the center was closed for renovation. However, the educational director was able to teach a group of students about the leaders of STEM in the past by using her excellent storytelling skills which kept them engaged.

We visited the family hands-on Thanksgiving event. The task for the day was to design Thanksgiving placements using simple materials such as felt paper, glue paper, and file folders. There, children can make their own designs from the precut shapes; however, students were able to make their own shapes. There was a process involved in this design task, but it was not as structured as the BBW process. There was more room to create other products from the given materials.

We anticipated observing several families, but arrived and learnt that the museum has challenges getting families and youth to attend their events. Since there were not any families at the placemat making event, we observed and took notes on the site and its various design elements. As with the BBW site there was a facilitator at the building event. However, unlike the BBW associates the facilitator at the African American History museum served as both activity facilitator and storytelling educator throughout the process. She is called "mama" and she provides a unique additional role in connecting the participants design and creativity to historical fictional and non-fiction stories of African American and African history.

The Michigan Science Center

The *Science Center has* hands-on engagement opportunities for visitors of all ages. Some of the engagement opportunities include: a 4D theater, a Planetarium, over 250 hands-on exhibits, lab activities, and STEM related live shows. The Science Center's mission is to "to inspire curious minds of all ages to discover, explore and appreciate science, technology, engineering and math (STEM) in a creative, dynamic learning environment [11]." This site was selected because of the many opportunities to observe African American youth engage in activities that were explicitly related to STEM concepts and because of its location in an urban center. For reference, it is located on the same city block as the African American History museum. The observations were made on a typical Saturday, there were no special events at the venue that day. The Science Center is located near a downtown Urban City.

Reflection

As opposed to the African American History Museum, the Science Museum had many families. We observed one of the largest groups attending the museum was a Boy Scout troop, which included both the scouts and the adult den leaders. We observed an African American father son pair engage with STEM displays together. Like this scenario, there were a plethora of other opportunities for parents and children to engage, discuss, and play with various activities. Some examples of youth engaging with exhibit by themselves, with friends, and family included:

- Their parents and their children playing in the STEM playground and building castles and various structures out of large Lego blocks.
- A Black family (a dad, mom, and a son) building a structure together.
- There were two men with two boys (one of the boys was Black) from Boy Scouts testing materials and performing calculations to determine which materials were strong enough to make small ramp that could transport marbles to a cup.

American Girl Retail Store

American Girl is a business that "develop[s] products and experiences that help girls grow up in a wholesome way, while encouraging them to enjoy girlhood through fun and enchanting play. The company has 20 retail stores that provide "special place for girls to make lasting memories with their families and friends." This site was selected because we anticipated it might provide us insight into a non-traditional settings were young girls might engage in designing, building and creating activities. This store was located in a suburb of Urban City.

Reflection

The store encouraged girls to use their imaginations to be become anything they want to become (i.e., soccer player, dancer, ice skater, gymnast, or a cinematographer). The American Girl (AG) store is located in a suburb of an Urban City and due to the location the likelihood of seeing a large sample of Black youth and families is low. There was one Hispanic family and one Black family in the store during the observation time.

Of the large selection of dolls in the store, there were 17 Black dolls in the store. The dolls seemed to moderately represent the diversity of girls of color. For example, eleven dolls had straightened hair and six dolls had natural hair styles. It is important to note that a regular doll costs $115. Some additional details about the dolls available include:

- There weren't as much of the dolls involved in science. There was one display with two dolls (one Black and one White) holding a telescope and a mini poster board about astronomy.
- Black dolls appeared more frequently as athletes than academics.
- American girl has a line of dolls called Wellie Wishers. One of the Wellie Wishers was a Black doll named Kendall. Her description was that she likes to make gifts for her friends. She has a ruler, safety glasses, measuring tape, and a piece of a quilt. She also invents.

The girls engaged in designing, building, or creating alone, with friends, or with their family. Girls were accompanied by their parents (mostly mother figures); however, the girls were more often dictating activities and process than parents.

The American Girl store also publishes material in addition to selling customizable dolls. American girl was selling books in the store on topics related to handling gossip, making friends, caring for one's body and handling technology and social media. During observation of youth at the American girl store, the girls did not engage in an obvious design process but were able to employ their imagination as they selected their dolls and accessories. This was a less structured design experience that both the BBW and the African American history Museum.

Discussion

In this exploratory critical ethnography, we sought to pilot the study and identify settings within which two engineering development sociocultural practices can be developed. In a previous study, participants reported developing engineering attributes because of these practices. We believed it is important to further validate their experiences and explore the potential that there might exist African American cultural norms around these practices by designing an

ethnographic study to observe these practices in situ. Here we discuss our observations in light of the guiding research questions:

1. How do Black youth develop engineering skills within diverse sociocultural informal contexts?
2. What does engineering learning look like in these informal contexts?

We wanted to see if students can acquire engineering skills in formal and informal settings by observing the 15 practices being used by students in multiple environments. Of the four sites that we observed, we saw that with each site, had a various form of process and structure in place. Build-a-Bear and the placemat making at the Museum of African American History, for example, took a child throughout a series of steps to create a finished product (e.g. a stuffed animal or a placemat). Throughout the process, there was some variation involved where the child can choose to skip certain steps if it was not necessary to obtain the product that was desired. In addition to different pathways, students were allowed to use the engineering skills of creativity and design. These sites allowed for various levels of creativity and allowed them to use the resources available to achieve their desired designs. The children also went through multiple iterations of prototypes to achieve it.

Parental support is very critical in building the foundation for success in STEM. It has been stereotyped that Black parents are distant from their children's educational endeavors. However, we found both in previous cases and in our observations that parents are aware of the circumstances of education and the importance of their children receiving it. Observed throughout of all sites, we see that parents were there with their children throughout the whole process to complete certain tasks. Some parents helped with the design process and brought their children suggestions of what would make the product better or more appealing. If the child encountered a problem, the parent was able to guide that child through it and was able to solve it. In addition to parents helping the students, we observed the sense of community also helped children succeed and facilitated learning in the observed context.

Implications of Parent-child interactions in STEM learning settings on formal learning

African American parents who are aware of educational inequities and additional societal pressures that their children are likely to face become "advocates, motivators, and early teachers [9]." They also teach their children how to navigate and advocate for themselves in racialized systems, including school and higher educational settings. More work must be done to understand the efficacy of parents' roles on the STEM pathways and experiences of African American youth. But current research supports that parents increased involvement and deliberate encouragement of both technical and knowledge and affective factors positively influence black youth success along STEM pathways. In fact, the impactful yet underexplored sociocultural practices of Black families promote positive matriculation through academic pathways and the development of STEM identities [6, 13].

Future Work

We will extend this work beyond researcher reflections to include a strategically design observational protocol, follow-up interviews and in depth analysis. Currently, we have observed two of the 15 practices. In the next phase of this work, we will include other data collection methods such as on-site interviews with the youth as well as their family members. For sites such as the science museum, we will dedicate time to observe specific sections of interest. We will continue to identify and explore different practices and settings as we begin to develop an understanding of the engineering ecosystem of Black youth. With respect to settings, we plan to include both "Black Spaces" and spaces that are not explicitly culturally specific. It is of great interest to our team to explore spaces where there is a high concentration of Black and URM communities.

We anticipate that future findings will not only validate the participant reports from the previous study, but will also highlight the ways that these practices develop specific skills and allow access to capital. This will contribute to other scholarship at the intersection of African American parent roles and cultural capital. Along with providing insights into the role parents can serve on STEM pathways, the findings from this work can provide educators with strategies to connect students' real-world experiences to classroom content and structure [1]. As this research is advanced, the implications of this work can help to strengthen our understanding of Black youths' engineering learning ecosystems [1], which is partly influenced by their community, culture, educational policy, formal learning contexts, and informal learning experiences.

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