What They Say: Black Children Talk About Learning Engineering

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Abstract— **What are the lived experiences of Black children that foster Engineer of 2020 attributes? Using a framework, which includes Community Cultural Wealth theory and the Engineer of 2020 attributes, the lived experiences of 8 middle school children were explored. In effort to identify these experiences, we build precious work and explore the ways that Black children describe their informal engineering learning experiences. In this qualitative study, we will analyze eight interviews from Black and mixed- race middle school aged children from two different regions of the United States. Using narrative inquiry, the data will be explored to understand the stories children tell about their informal engineering learning experiences. We anticipate validating findings from previous work and shedding light on additional practices within the Black community that foster engineering attributes in middle school children. The anticipated contributions of this work are two-fold. Primarily, the findings of this work inform the interview protocol for a larger study investigating the ways the Engineer of 2020 attributes can be fostered in Black males through their precollege lived experiences. Additionally, this work can provide evidence for the diverse ways that Black children can learn engineering within their own communities. With this evidence, educators and engineering education researchers can establish stronger connections between students' lived experiences and the classroom and potentially increase interest in engineering careers and degrees among Black children.**

Keywords—African American; Engineering; Informal Learning; Narrative Analysis

I. INTRODUCTION

Studies investigating Black children's access to and learning of engineering knowledge often focus on formal and structured informal learning settings, such as Engineering curriculum in schools and First Robotics. In many cases, educational researchers and evaluators have explored the impact of these experiences on engineering identity, efficacy, and engineering knowledge. They have found positive relationships between engineering interventions and the aforementioned measures. Research in this space is needed because of what some scholars call the "leaky pipeline" which characterizes the loss of historically underrepresented students as they matriculate from pre-kindergarten to completion of the engineering degree. However, an understanding of engineering learning that is restricted to material taught in formal or informal established learning settings can undervalue the evidence of children learning diverse skills through common community practices. Frameworks embracing diverse skills developed in community practices indicate that there is a need for more research to understand the role community practices can play in children developing needed skills and knowledge [1-3]. Research investigating Black children's lived experiences and the influence of their experiences on their engineering identity and pathway, is needed because children of different racial and socioeconomic backgrounds have differing access to out-of-school activities. Cardella [4] has also shown that youth spend only 18-25% of their out-of-school time in formal settings. These findings demonstrate the need to understand and identify everyday practices that influence Black children's engineering learning and engineering pathway.

This paper explores eight Black children's perceptions of engineering, which was characterized as building, creating and designing through on-on-on interviews. Many of the interviews took place in in their homes. The purpose of the study is to use the Community Cultural Wealth framework to identify the lived experiences of Black children that foster Engineer of 2020 attributes [5]. Using a framework, which includes Community Cultural Wealth theory and the Engineer of 2020 attributes, we situated the Engineer of 2020 attributes within scholarship on Black communities and found evidence that these attributes can be fostered through everyday experiences. However, what is missing from the literature is explicit connections made between the African American cultural practices and engineering knowledge. In effort to identify this connection, this work builds upon previous work [6] and explores that ways that Black children narrate their informal engineering learning experiences.

II. RESEARCH QUESTIONS

The objective of the present study to explore the ways the Black children develop engineering attributes through their lived experiences as shared in one-on-one interviews. In the context of this study, engineering has been operationalized as designing, building, and creating. The research question for this work is: How do Black/African American middle school

children describe their out-of-school-time engineering learning experiences?

III. Methods

A. Data Collection and Participants

The sample of children (N=8) discussed in this study is drawn from existing data from a NSF study which explores middle school aged children's individual experiences with engineering in informal learning contexts through building, creating, and designing. The NSF study recruited 60 middle school children and sought to achieve diversity in terms of socio-economic status, ethnicity, geography (e.g., urban, rural, suburban) and schooling (traditionally, homeschooled). For the purposes of this investigation, only participants who identified as Black or African American were included in the sample of data analyzed and discussed in this paper. The middle school aged participants were interviewed by multiple people. Each child had some experience related to designing, creating, or building before they began participating in the study. The interview data from the first interview will be presented in this paper.

IV. Data Analysis

In the exploratory qualitative study presented in this paper, we analyzed eight interviews from Black and mixed - race middle school aged children, which include two female participants and six male participants. Using Narrative Inquiry, the data will be interrogated to understand the stories children tell about their informal engineering learning experiences. Each interview was coded using a priori codes which emerged from literature, Community Cultural Wealth theory, and the Engineer of 2020 attributes (see table 1). For each participant, detailed narratives where written by the researchers in third person to enable high narrator reliability and high authorial distance, using a storytelling approach [7,8].

Interviews were transcribed prior to the investigation and were reread multiple times during analysis. During the first read, general observations and memos were recorded for each transcript. Following the first read of all transcripts, they were segmented at major punctuation marks and given line numbers, in order to create distinct units of text to analyze. During the second analysis phase, all the segments of one transcript were re-read and segments that seemed to connect to the research question and/or were particularly striking were noted and compared to the existing codes which were developed from the theoretical frameworks. Once it was determined that all relevant themes had emerged, the final coding scheme was established and the final seven transcripts were coded using the codes detailed in in table 1.

V. Results

This study is still in the analysis phase so preliminary results are shared in this paper. Seven of the eight children have engineering interest outside of school but each of their experiences take different shape. For example, engineering was experienced either with a group or alone. The participants shared experiences of doing engineering with family members and friends. Carter reflects on this point, *"I do like building. My dad is a carpenter, so I like building. On the other ... hand my brother is really good at technology, so I like to play games and computer[s] and stuff... but I do like to go to work with my dad and we like making like fences, tiles, floors, we take out walls, and put in new ones*." This is an example of how the Carter engages in engineering activities with his father and this feeds his interest. This excerpt also, highlights another insight from the preliminary analysis. The role of the parent as supporter. Some participants like Carter shared specific instances of working with a parent but other children shared that their parents gave them resources to engage in engineering or even simply encouraged them to design, build, and create by enrolling them in extracurricular activities. Tristan and Laura provide examples of the informal engineering activities that their parents or school provided for them.

Tristan gives some insight in to the extracurricular engineering program his mom enrolled him in, *"...in April vacation*

Table 1: Coding Scheme

Community Cultural Wealth	Engineer of 2020 Attributes	Emergent Themes
• Aspirational capital	• Analytical skills	• Racial identity
• Navigational capital	• Business & management skills	• Parent\Community Leader\Educator
• Linguistic capital	• Communication & teamwork skills	• Values (interests and activities)
• Social capital	• Creativity	• Attitudes (view of self)
• Familial capital	• Dynamism	• Beliefs (future engineering career)
• Resistant capital	• High ethical standards	
	• Professionalism	
	• Leadership	
	• Practical Ingenuity	
	• Lifelong learners	
	• Mathematics and science knowledge	

sometimes I go to this program and we'll make memory chips and chips of robots and make them move and what-not."

Laura attends a school that has a collaboration with Google and she participated in a "Doodle for Google" design competition. Laura describes the competition and her submission, *"They give you like this – they give a --For example like this chair if you could create one thing to make the world a better place what would it be? So you basically draw something. I did like a machine that would give you what you needed most in life."*

Other ways that the children's interest and activities linked to engineering learning was through video games, Legos and art (i.e., origami & drawing). With respect to video games all of the participants played with a virtual reality game called Minecraft. Some children commented that they played Minecraft because they liked having the ability to build whatever they needed and imagined. Phillip reflected on why he likes playing Minecraft, *"I like building, like structures and stuff, like temples or something."* Several children expressed interest in and activities which aligned with building what was "*in their head."*

Both video games and Legos provide opportunities for the children to create. Adam talks about his experience making a lightbulb and why building is interesting, "*What's interesting is that I get to build. It's how I get to be hands on [with] them and working with them and like putting them on a job … it's like going out [and getting] stuff and making it like I made a light bulb once and it wasn't quite hard…"*

The children listed many activities that they were interested in and participated in during their out-of-school time. Many of their experiences aligned with previous work which investigated Black children's use of afterschool time and school engagement [9]. For example, Adam had many interests including: playing video games, building, family outdoors activities, visiting museums, watching building television shows, rock collecting, and helping his mom file paperwork for her law firm. The other participants shared similar interests.

The activities that the participants experienced were mapped to the six aspects of Community Cultural Wealth and the Engineer of 2020 attributes. From Adam's data, the following Engineer of 2020 attributes emerged: Business and Management, Communication, Creativity, Dynamism, High Ethical Standards, Leadership, Lifelong Learning, Math and Science Knowledge, Practical Ingenuity, and Strong Analytical Skills. The following aspects of Community Cultural Wealth codes were identified in the data: Aspirational, Familial, Linguistic, Navigational, and Social Capital. Here is an excerpt from Adam's final narrative, which will give insight into how Communication and Aspirational Capital emerged from his interview responses.

Communication:

Adam values his **communication** and considers himself a *"good writer."* He seems to have a command of argumentation because his mom calls him Mr. Obama and a "mini-politician." She also acknowledges his writing and storytelling and her role in guiding him to becoming a critical thinker as he exercises his communication skills. She reflects that he often sees concepts on TV or through other forms of media and he pieces them together and treats them as objective truth. She feels it is important that he understands how to reflect and use the information that he is taking in. When Adam is using verbal communication he expresses difficulty speaking concisely. Specifically, Adam *"use[s] a whole bunch of other different words" when he "can't think of that [one] word."*

Aspirational Capital:

Aspirational Capital as defined by Yosso [3] is "resiliency, the ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers." Adam's access to **aspirational capital** came through his experiences solving difficult problems or challenges that other people gave up on. He demonstrates an ability to face a challenging task and envision approaches to solving it. Adam's mom shares*, "he will stay on it for days and weeks until he tires of it and that may take a while."* Aspirational Capital also emerges from the Adam's ability to persevere while he is learning a new skillset. Adam shared his experiences learning to play the trumpet. After less than two months of playing the trumpet, he says, *"I wasn't good at first but now, I am well, kind of good!"* This is an example of confidence and aspirational capital working in tandem.

VI. Discussion

The students shared everyday experiences which aligned with engineering practices and learning as evidenced by the Engineer of 2020 attributes. These experiences also showed evidence that the Black children in this study had access to different forms of capital. These preliminary findings suggest that informal cultural practices can be conduits of engineering learning in the Black community. This work builds upon previous work that acknowledged the presence of funds of knowledge and community cultural capital in the Black community. Additionally, the preliminary findings from the work begin to address the gap in our current understanding of the relevance of knowledge learned from cultural practice to the engineering pathway.

VII. Conclusion

A growing number of scholars are interested in how to address the "leaky engineering pipeline." Individuals enter this pipeline at various points and exit at various points; therefore, every point of the pipeline is critical. This study was intended

to contribute to these research efforts and to understanding access to engineering by providing evidenced findings that reveal connections between lived experiences of Black youth and engineering traits. Furthermore, it is important that through this research the lived experiences of Black children are made known and valued. The students' interview responses along with data from the existing literature and transcripts can be used to develop robust characterizations of informal pre-college engineering activities that foster engineering attributes in the Black community and provide avenues to access Community Cultural Wealth. This work can contribute additional evidence for the diverse ways that Black/African American children can learn engineering within their own communities. With this evidence, educators and engineering education researchers can establish stronger connections between students' lived experiences and the classroom and potentially increase interest and retention in the engineering pathway within the Black community.

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