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Styling STEM: How African American Women Cosmetologists Can Help to Reimagine STEM Education

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ABSTRACT

This paper analyzes interviews with African American women cosmetologists who collaborated in designing and implementing a series of community-centered science, technology, engineering, and mathematics (STEM) education programs to support broadening the participation of Black children in those fields. These collaborations used technologies and media as bridges between STEM knowledge as it appears in schools and STEM knowledge as it has been and is communicated, produced, and used by Black hair care experts. We discuss how acknowledging these experts as knowledge producers who have unique pedagogical expertise not only provides new ways for reimagining STEM fields for Black children, but also helps to acknowledge STEM's existing and generative presence in Black communities. Our findings reveal three ways that this group of African American cosmetologists helped reimagine STEM education: 1) STEM as personal and situated; 2) STEM as a blend of public and community institutions and 3) STEM as community.

KEYWORDS

African American women, Black feminist epistemology, Black hair care, community-centered STEM, cosmetology, STEM education

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INTRODUCTION

There is a growing amount of literature on the ways that anti-Black racism and patriarchy are embedded within and get reproduced through the values, practices, norms, content, and conceptual infrastructure of science, technology, engineering, and mathematics (STEM) education and professions (Bowers, 2016; McGee, 2020; Prescod-Weinstein, 2020; Rankin & Thomas, 2019; Scott & Elliot, 2019). This includes the conceptual infrastructure of the STEM "pipeline" which invokes images of people as resources to be extracted and refined for the interests of capital and the state (Lachney et al., 2021a). For example, Scott and Elliot (2019) explain how broadening participation programs in computer science education can "enable a *labor system* for computing that poises women of color as commodities used to enrich others" (p. 376). Anti-black racism is also found in the obduracy of racialized language in computational systems (Eglash, 2007) and anti-Black microaggressions that are ingrained into the culture of U.S. engineering (Lee et al., 2020). Even if Black women make it through the STEM education pipeline and into the workforce, they may continue to face racist ideologies and Eurocentric values that do not support their wellbeing nor consider the knowledge they bring with them as assets to STEM fields (Brown et al., 2020; Rankin et al., 2021). Therefore, while the goals of racial and gender diversity and inclusion are important, they often do not go far enough to seriously confront the barriers and exclusionary structures of STEM. For these reasons and others, education scholars such as Emdin (2022) have argued that there is a need to "reimagine" STEM education and professions.

If we take calls to reimagine STEM in ways that are affirming of Black girls, women, and their communities seriously, where can we turn to learn about what an alternative STEM might look like? We argue that the knowledge and practices of the African American women cosmetologists in this study provide a model for reimagining STEM. We draw on Black feminist theory and epistemologies (Collins, 2009) to center African American women as knowledge producers who have expertise that is relevant to STEM and pedagogy. This framing not only provides new ways for thinking about broadening the participation of Black children in STEM fields, but also for thinking about how STEM content and knowledge are already embedded in Black cultural and community practices.

We make these cases through analyzing interviews collected during a series of collaborations from 2016-2018 between educational researchers, technologists, African American cosmetologists, and cosmetology students. The goal of these collaborations was to reimagine the shape and culture of STEM education in ways that were community-centered and affirming of Black girls' and women's identities. We report on what the researchers and technologists learned about pedagogy and STEM from the cosmetologists and cosmetology students during these collaborations. These insights helped to inform the design and implementation of two STEM-cosmetology projects: Cornrow Curves and pH Empowered. Part of this learning process was about acknowledging how the collaborations built on a long history of knowledge production and innovation by Black hair care experts (Byrd &

Tharps 2014). We introduce some of this history before exploring how the collaborations were focused on using computational technologies and digital media as bridges between the ways that STEM content appears in schools and the ways that STEM knowledge is communicated, produced, and used by four African American women cosmetologists in a northeastern U.S. city. We found that the four women engaged in and valued education that bridged in-school and out-of-school opportunities for learning. We also found that of all the STEM subjects, they most readily identified their expertise with anatomy, physiology, and chemistry. We introduce three ways that the four women's perspectives and ideas can help us to reimagine STEM for Black children: 1) STEM as personal and situated; 2) STEM as a blend of public and community institutions; and 3) STEM as community.

BLACK FEMINIST EPISTEMOLOGIES & BLACK HAIR CARE

It is important that we begin by highlighting the history and diversity of Black hair care expertise and knowledge production that we as educational researchers and technologists built upon and referenced (explicitly or implicitly) throughout the collaborations with the cosmetologists in this study, as well as during data analysis. Prior ethnographic research and cultural studies about Black hair care practices and styling in the U.S., highlight how hair salons operate as dynamic communities and important cultural sites for relationship building, knowledge production, innovation, and sociopolitical discourse (Banks, 2000; Byrd & Tharps, 2014; Dabiri, 2019; Ford, 2015; Gill, 2010; Majors, 2015; Mercer, 2000). For Black women and girls in particular, this research details the convergent and divergent ways that they may make sense of hair in relation to social and cultural issues surrounding beauty, identity, and power, all the while engaging in complex problem-solving to help navigate a Eurocentric world (Banks, 2000; Majors, 2015). For example, in Banks's (2000) ethnographic work *Hair Matters,* African American women and girls articulated shared experiences of living in the U.S. where Eurocentric standards are dominant but negotiated the practices of straightening hair or wearing natural styles, and the implications for identity and femininity, using diverse knowledges that spanned physical and metaphysical levels.

Historically, Gill (2010) explains that African American women's beauty salons and schools in the 20th-century supported economic and physical autonomy that made them incubators for political thought, activism, and organizing. Beauticians played important roles in Marcus Garvey's Universal Negro Improvement Association, the Black socialist movement in the 1930s, the maintenance of the National Association for the Advancement of Colored People, voting registration campaigns in the 1950s and 1960s, and much more. African American beauty entrepreneurs also contributed to producing knowledge about business and economics, including creating international trade and business relations in the fields of beauty, fashion, design, and hair care (Byrd & Tharps, 2014). Facing inhospitable conditions at home due to racism and discrimination, these industry trailblazers used their business acumen and relationships forged abroad to advance their economic pursuits at home (McAndrew, 2010).

These overviews of the cultural, historical, economic, and political aspects of Black beauty and hair care are not meant to suggest that Black or African American

women share unified, essential, or homogenous knowledge. Instead, given their shared experiences with white supremacy, patriarchy, and anti-Black racism in a U.S. context, Black and African American women have used and continue to use their diverse experiences and validation methods to produce heterogeneous knowledge forms and innovative practices that enable survival, resistance, and flourishing amidst these intersecting systems of power (Collins, 2009). Due to patterns of suppression, the works and thoughts of these women are not always locatable in the institutions that are commonly associated with knowledge production (e.g. industry or academia). Collins (2009) explains that within the history of Black feminist thought, there are two interdependent levels of knowledge production. First is a fundamental level of knowledge that is often taken for granted and grows out of everyday thoughts and actions. Here, we might think of the cultural communities of Black hair salons and everyday hairstyling and beauty practices that are described above.

Second are more specialized levels of knowledge that emerge from the fundamental level. Consider, for example, 20th-century cosmetic industry entrepreneurs such as Annie Turnbo Malone and Madam C. J. Walker. They are well-known names but situated within communities of men and women who did not make it into history textbooks but nonetheless helped to shape their successes. In the early 1900s, Walker sold and used cosmetic products, gaining knowledge about chemistry and business that would later support her entrepreneurial success (Bundles, 2001). She became the first African American woman millionaire in the U.S. and founder of the Madam C. J. Walker Manufacturing Company (Bundles, 2012). While Walker is well known for popularizing knowledge and technologies for straightening hair, she also played important roles in funding Black economic, educational, civic, social, and political organizations (Byrd & Tharps, 2014).

Walker was not the only specialized knowledge producing beautician in the 20th-century who became important in activism and political participation (Gill, 2010). As part of a voter registration campaign in 1957, Charleston beautician Bernice Robinson taught her first literacy class for the Highlander Folk School's Citizenship School for civil rights organizing (Russell, 2011). With prompting from civil rights activist and Robinson's cousin Septima Clark, the founder of Highlander, Myles Horton, hired Robinson with the idea that: "Bernice was a black beautician. Compared to white beauticians, black beauticians had status in their communities. They had a higher-than-average education and, because they owned their businesses, they didn't depend upon whites for their incomes" (Horton, 1997, p. 102). Robinson went on to become a supervisor of the Low Country Citizenship Schools and was the first African American woman to run for South Carolina’s state house of representatives.

These traditions of exchange between everyday and specialized levels of knowledge production continue today in work such as the PsychoHairapy program created by clinical psychologist and natural hairstylist, Dr. Afiya Mbilishaka (2018). Bringing together their different areas of expertise, Mbilishaka and colleagues offer hair-based education for teachers, youth, psychologists, hairstylists, and others that center on understanding and supporting Black women's mental health and

wellbeing (Mbilishaka et al., 2020). One part of this program taps into the natural hair movement, which became popular in the 1960s and again in the early 2000s and continues today. This movement represents a unique thread of knowledge production and circulation for connecting people of African descent at global and local levels (Ford, 2015). Another part of this work is about recognizing and challenging anti-Black hair discrimination in the 21st-century by contributing to mental health awareness, supporting legislation to combat racism in schools and workplaces, and mobilizing with groups such as The CROWN coalition (McClendon, 2021).

BLACK HAIRSTYLISTS AS EDUCATIONAL KNOWLEDGE PRODUCERS

We now turn to a specific area of knowledge production that Black hair care experts have contributed to: education. From Madam C.J. Walker to Dr. Afiya Mbilishaka, Black beauticians, cosmetologists, and hairstylists have made and continue to make significant contributions to teaching and learning in African American communities across the United States. Walker's philanthropy supported African American education at multiple levels and across disciplines. Directly related to cosmetology education, by the late 1920s Walker Beauty Schools taught African American women about "Beauty Culture" in Chicago, Indianapolis, Cleveland, St. Louis, and other U.S. cities (Bundles, 2012, p. 48). Back to the context of Highlander, the knowledge that Robinson brought to literacy education and campaigns was so important that she, Clark, Horton, and others aimed to scale the model up by holding workshops exclusively for beauticians in the early 1960s (Gill, 2010, pp. 115-117). Here Robinson describes her active participation approach to learning: "I'm really not going to be your teacher. We're going to work together and teach each other" (Robinson quoted in Gill, 2010, p. 113). The fact that Black beauticians and hairstylists have unique pedagogical expertise and knowledge relevant to engaging African American communities has not been lost on 21st-century educational researchers.

For example, in her book *ShopTalk: Lessons in Teaching from an African American Hair Salon,* Major's (2015) explores what educators might learn from the cultural socialization and problem-solving processes that take place between expert and novice salon workers, as well as between workers and their clients. The phenomenon of Shoptalk may sound deceptively simple, but it often includes narratives and counter-narratives to support complex cultural and linguistic modes of problem-solving through "*dialogically structured arguments*"; that is to say, they are "multivoiced responses to a proposition that has been posed and interpreted in light of opposing systems of values and propositions of power" (Majors, 2015, p. 37). Consistent with Collins's (2009) articulation of Black feminist epistemologies, these dialogical relationships use culturally situated forms of knowledge validation.

Emdin (2016) extends this idea, making the case that U.S. educators, including pre-service teachers, can learn from not only Black cosmetologists in the salon but also barbers in the barbershop. Recognizing and confronting the challenges of a predominately white teacher workforce and school systems informed by histories of anti-Black racism, Emdin introduces the idea of *Pentecostal pedagogy* to help teachers think about methods for engaging Black children in their classrooms. His

reference is a style of communicating that applies to quality teaching regardless of religious beliefs (indeed, its origins are in African animist cultures (Reed, 2012)). In discussing the musical and ecstatic worship practices of Black Pentecostal churches (see Gates, Jr., 2021), Emdin (2016) encourages educators to study preachers' methods of call-and-response, as well as how and when they change tone and inflection during different times of a sermon. He goes on to suggest that barbers and cosmetologists are also sources of knowledge for Pentecostal pedagogy: "By studying Pentecostal pedagogy and the ways it is expressed in places like barbershops and beauty salons, the educator learns how to value voice and foster family within the classroom" (Emdin, 2016, p. 59). The goal is to help teachers transform classrooms into spaces where students' voices are valued and reciprocal learning can take place within a shared community. Indeed, Emdin's Pentecostal pedagogy would probably have some similarities with Robinson's "teach each other" approach. Yet, there has been little work to explore how Black cosmetologists, braiders, and general hairstylist might contribute to the project of broadening participation in STEM; a surprising fact considering the centrality of chemistry, anatomy, and physiology to cosmetology expertise and education (e.g., Bailey & Da Costa, 2013; Milady, 2015).

RESEARCH QUESTIONS

Building on the history of knowledge production by Black hair care experts, we ask: What are some ways that African American cosmetologists can help to reimagine STEM for Black girls and women? We aim to provide an answer to this general question by introducing and answering two more specific research questions:

1) *What types of educational experiences (i.e., experiences of teaching and learning) do cosmetologists value?* Four cosmetologists and two cosmetology students were asked to reflect on their past and present educational experiences. We studied their articulations of these experiences to help rethink the epistemic, cultural, and social boundaries of STEM education.

2) *How do cosmetologists and cosmetology students conceptualize their knowledge in relation to STEM?* Across the collaborations, cosmetologists and students explained their attitudes toward STEM and explored how STEM relates to cosmetology. From these insights we want to learn how mainstream conceptions of STEM converge and diverge from these cosmetologists' and students' knowledge and practices.

CONTEXT & METHODS

Research Context & Participants

In this paper, we draw on data collected from spring 2016 to summer 2018 with four African American women cosmetologists who helped design and implement STEM-cosmetology programs for in-school, after-school, and out-of-school settings (figure 1). Also included in our data are interviews with two high school cosmetology students (one African American girl and one multiracial girl), both of whom participated in three of the STEM-cosmetology programs, including being

hired as mentors to help younger children at an out-of-school program. These collaborations were organized around the design and implementation of two educational technologies and websites: Cornrow Curves and pH Empowered.

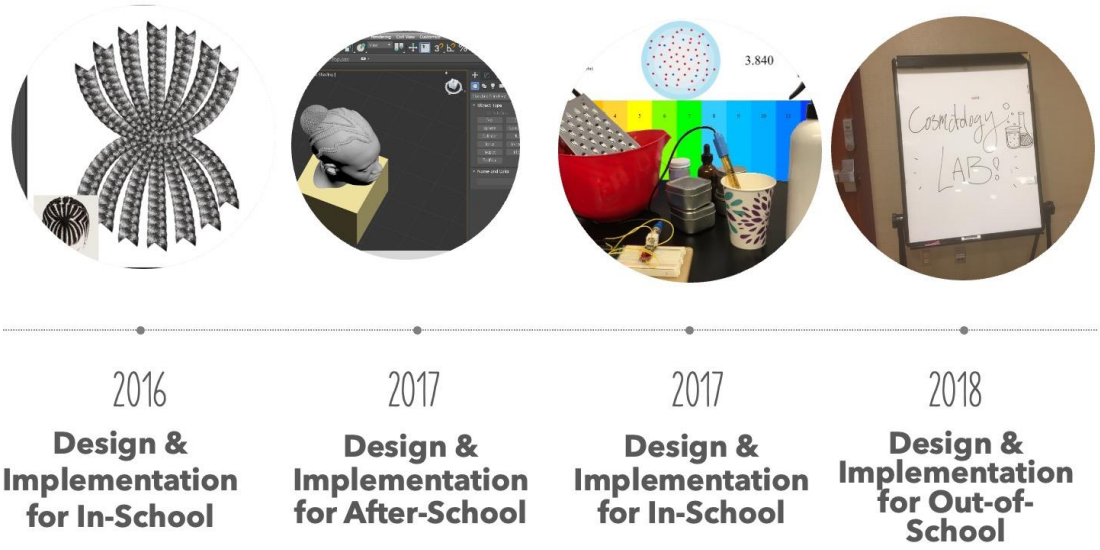

Figure 1. A timeline of the collaborations

The Cornrow Curves project (figure 2) is part of a larger suite of applications designed to explore Indigenous and vernacular knowledge, called *culturally situated design tools*. Cornrow Curves is currently represented as a visual programming application where users can make connections between an original body of African mathematics (see Eglash, 1999) and the adaptive scaling of cornrow braids (Eglash et al., 2006). This application has been widely explored inside and outside of STEM education research communities (e.g., Bennett et al., 2016; Dabiri, 2019; Eglash et al., 2013; Gaskins, 2019), including being popularized in schools through the Exploring Computer Science curriculum (Goode et al., 2020).

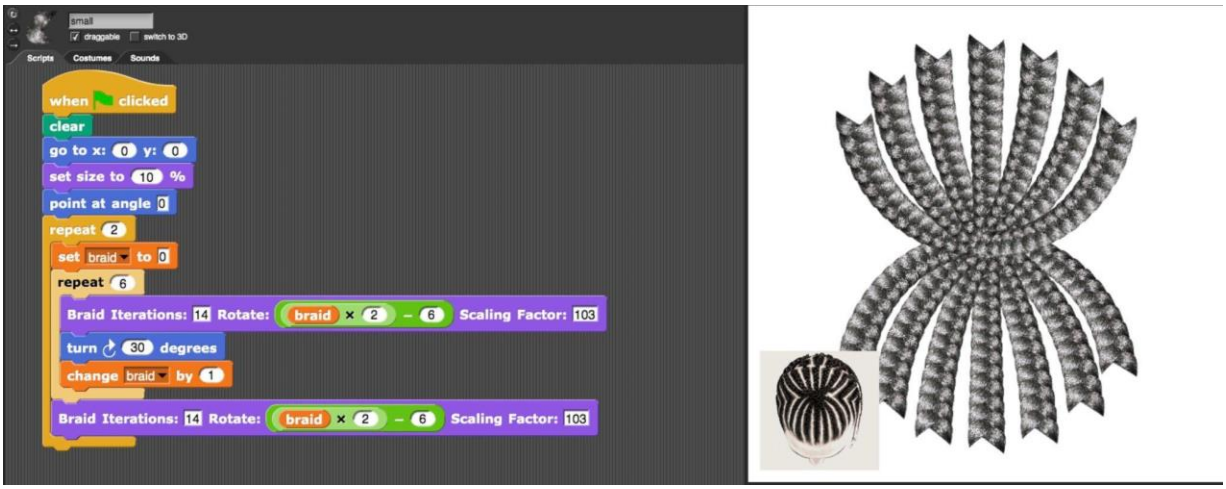

Figure 2. A Cornrow Curves design from the csdt.org website

The other project is called pH Empowered. Drawing on the knowledge of the pH of hair products that cosmetologists use in their salons, the project used pH sensing hardware and pH visualization software (figure 3) to explore connections between Black haircare, chemistry, and entrepreneurship (Lachney et al., 2021b). The project was designed in collaboration with hairstylists, which included running professional development programs with them to support their knowledge of the technology and to get their feedback on the project itself (Lachney et al., 2021c).

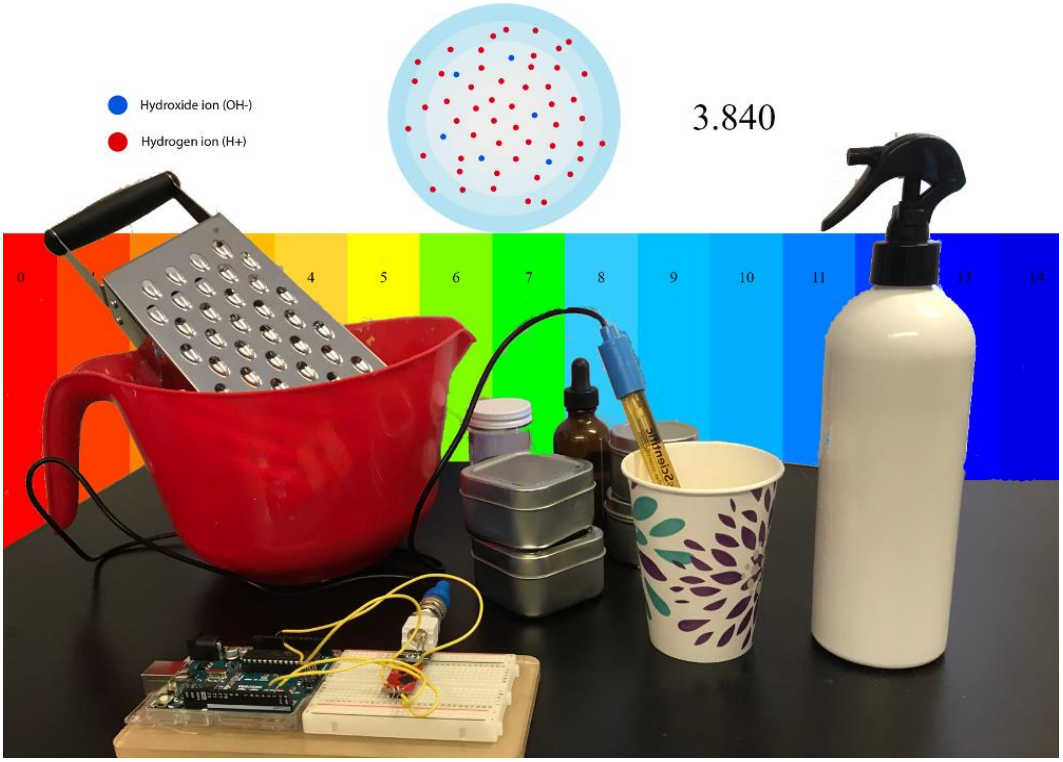

Figure 3. pH sensor connected to an Arduino microcontroller with a customized visualizer in the background

Table 1 is a breakdown of the STEM-cosmetology program implementations between 2016-2018 that included collaborations with one or more of the four professional cosmetologists. Except for the spring 2018 professional development program, all the programs we report on in this paper took place in one northeastern U.S. city. All these programs, in-school or not, geographically took place within the boundaries of one school district that serves approximately 8000 students across K-12, with Black children making up approximately 45% of the student population. The spring 2018 professional development program took place at a university campus within driving distance from the city. Fifteen interviews and eight debrief sessions were recorded and transcribed from across these collaborations.

Table 1: A breakdown of each implementation between 2016-2018.

Program Number	**Context**	**Season Year**	**Education Level**	**Activities**	**Interviewee (pseudonym)**
1	Technology course	Spring 2016	Middle School	Cornrow Curves	Erica
2	After-school cosmetology program	Spring 2017	High School	Cornrow Curves	Monique, Tonya, & Linda
3	Cosmetology course	Fall 2017	High School	pH Empowered	Monique, Tonya, & Linda
4	Professional development for cosmetologists	Spring 2018	Post-Secondary	Cornrow Curves & pH Empowered	Nichole & Erica
5	Summer library program	Summer 2018	Middle & High School	Cornrow Curves & pH Empowered	Nichole, Tonya, & Linda

The first program took place over two days during the spring of 2016. It was done in collaboration with Erica (pseudonym) and a middle school technology teacher. At the time of the collaboration, Erica owned a successful hair salon specializing in natural styles and chemical treatments. Erica provided input for both the design of the Cornrow Curves software and the lesson plan used during implementation. One interview was conducted with Erica after the implementation.

The second was an after-school Cornrow Curves program that took place over the course of a month and was designed in collaboration with the head of a cosmetology department, Monique (pseudonym). According to Monique, Black girls make up the majority of her cosmetology students. In addition to her responsibilities to the cosmetology department, Monique also ran a successful hair salon. Four interviews were collected with Monique while developing the program and eight recorded debrief sessions during the program. In addition, two of

Monique's students, Tonya (pseudonym; African American) and Linda (pseudonym; multiracial), participated in this program.

The third was a cosmetology course in the fall of 2017 that was developed for and carried out in Monique's classroom (figure 4); implementing the pH Empowered activities that she had helped to design the prior summer. Two reflective interviews with Tonya and Linda were conducted after their participation in this program to learn about what they liked and disliked. While designing and implementing the fall 2017 program, the research team got to know Monique's colleague and friend Nichole (pseudonym). Nichole works in Monique's salon and specializes in natural hair, natural hair products, and other cosmetic and hair practices (e.g., barbering). Nichole has also worked as a cosmetology instructor at secondary and postsecondary levels.

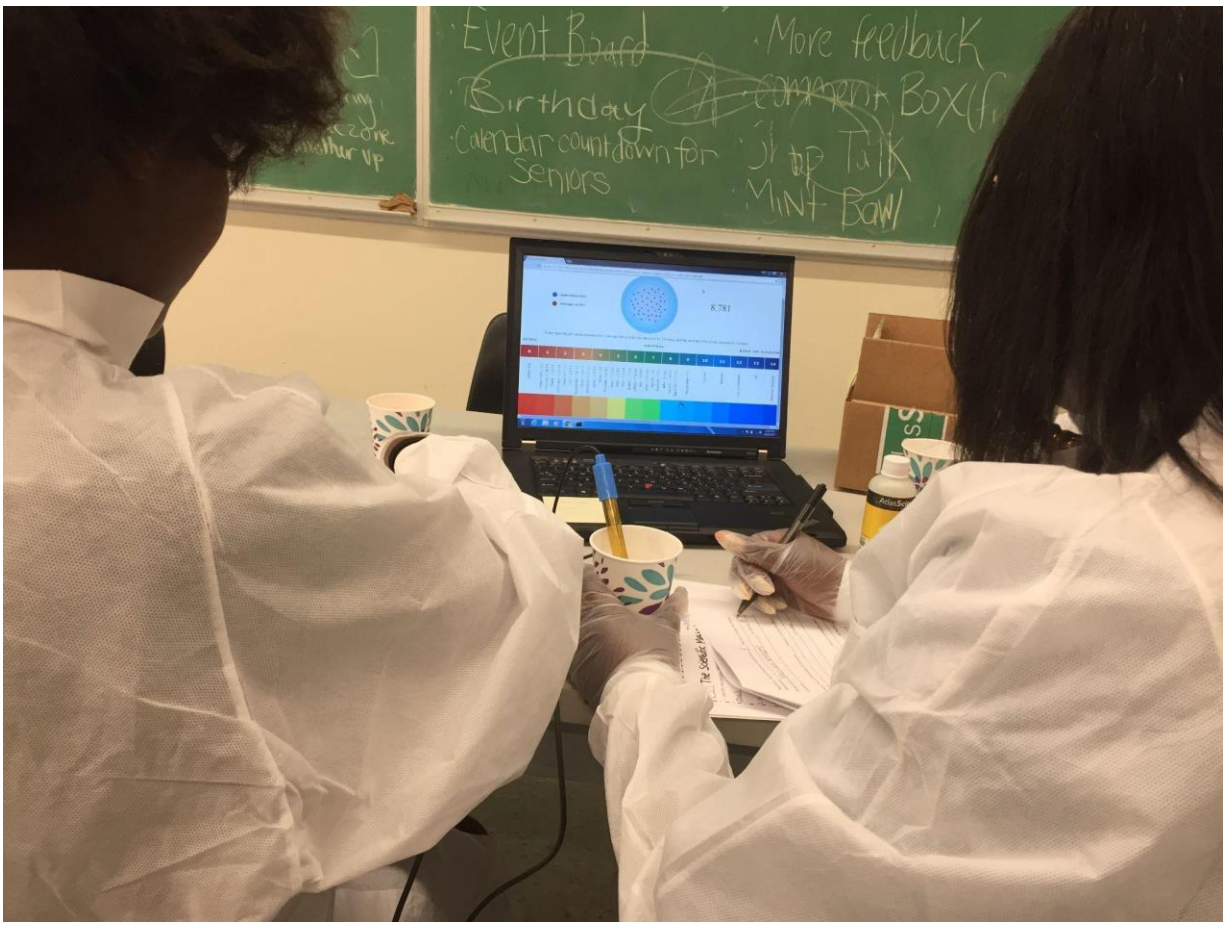

Figure 4. Two students work together in Monique's 2017 fall course to calibrate the pH sensor with pH visualizer software explicitly created for the course

For the spring 2018 program, Nichole helped to design and run a one-day professional development workshop for cosmetologists who were interested in collaborating with STEM teachers. Erica was in attendance as a workshop participant. And, for the fifth, Nichole helped to run a month-long summer library program. Five interviews were conducted with Nichole: one before the spring 2018

program, three after it, and one after the summer program. Most of these interviews focused on planning or reflecting on the programs, but the three interviews in between the spring and summer programs also included questions about Nichole's lived experiences, her expertise in cosmetology, and experiences in school as a learner and instructor. In addition to collaborating with Nichole during the summer library program, the research team also worked with another licensed cosmetologist, Vivian (pseudonym), who Nichole was mentoring at the time. With their prior experiences in STEM-cosmetology programs, Tonya and Linda were hired to help facilitate the summer program as high school mentors. Interviews to reflect on the summer program were conducted with Vivian, Tonya, and Linda upon its completion.

DATA COLLECTION & ANALYSIS

We answered our research questions by analyzing interviews with the cosmetologists and cosmetology students that were conducted by Lachney, the second author of this paper. The interviews were grounded in ethnographic methods (Allen, 2017), taking place in naturalistic settings and based on an established relationship between the interviewer and interviewees. The topics of the interviews that took place before the STEM-cosmetology programs were often determined by what the research team needed to learn about cosmetology in preparation to design lesson materials and support implementation. Sometimes these interviews included demonstrations of Cornrow Curves or pH Empowered, as well as learning about an individual's own cosmetology and education backgrounds. Interviews with adults following the programs were largely reflective and focused on what the research team could learn from perceived successes and failures of the implementations.

The interviews with adults lasted between approximately 20-40 minutes, except for the interviews with Nichole. Nichole's five interviews lasted approximately 80-110 minutes because of an explicit focus on her personal background beyond cosmetology and experiences beyond the STEM-cosmetology programs. In addition to these interviews, eight debriefs (ranging from 5-20 minutes) were conducted with Monique during the spring of 2017 after-school program, each immediately after implementation to reflect on the day's activities. Three of the interviews with Tonya and Linda lasted between approximately 10-18 minutes. One interview with Tonya was approximately 70 minutes. It took place after the 2018 summer library program. The extra time during this interview included discussions about her future education and career goals.

Each interview and debrief was recorded and transcribed before being analyzed using a combination of ethnographic coding and discourse analytic methods. Pictures and video recordings were also taken during the implementations. These along with follow-up email correspondence with cosmetology collaborators supplemented the transcripts to help the first author (i.e., Okonkwo) and second author (i.e., Lachney) to identify preliminary themes and patterns. This allowed us to "triangulate" by data sources and methods to help check the validity of our interpretations (Meijer et al., 2002). Four themes emerged that were relevant to answering our research questions: *science and creativity, opinions of STEM,*

applications of STEM, and *cosmetology education*. Table 2 is an explanation of the themes. Using a conversational method of "dialogical intersubjectivity" (Saldaña, 2016, p. 37)—i.e., "agreement through a rational discourse and reciprocal criticism between those interpreting a phenomenon" (Brinkmann & Kvale, 2015, p. 279)—the first author and second author met to discuss these themes and patterns as part of a more focused analysis to explicitly address the research questions, which we now answer below in the findings section. While all four themes informed our answers to the research questions, we primarily used the theme *cosmetology education* to answer the first research question, while *science and creativity, opinions of STEM,* and *applications of STEM* were used to answer the second research question.

Table 2: Themes, definitions, and excerpts

Theme	**Definition**	**Example of Coded Excerpt**
Science & Creativity	How science and creativity are do or do not work together in cosmetological work	"...there's so much creativity in cosmetology that if you are a creative being, you could find your niche."
Opinions of STEM	How participants feel about STEM, in relationship to their own work and identities	"Oh yeah. I feel like a scientist now. I could go out there – a scientist and a teacher now I feel like I can just conquer the world. Just kidding. No, but I do – I feel like I am a lot more knowledgeable in you know computer programming, geometry, hair braiding."
Applications of STEM	How science, technology, engineering and/or mathematics can be or are used in cosmetology	"There's always advances in technology like they have a dead end trimmer to where it looks like a flat iron and you put it like you use it as a flat iron but it trims your dead ends."
Cosmetology Education	How participants learned cosmetological skills in formal or informal settings	"I would say cosmetology and this may be just the way my teacher teaches it, definitely a lot more hands on, definitely a lot more independent and creative."

FINDINGS

What types of educational experiences (i.e. experiences of teaching and learning) do cosmetologists value?

All of the cosmetologists began doing hair in an informal manner before entering and completing cosmetology school. Three continued on to being entrepreneurs by either owning their own salons (i.e. Erica and Monique) or creating their own cosmetic products (i.e. Nichole). In a frequently changing world, hairstyling was often framed as something these women could continually rely on. For example, Erica explained that out of all the things she has tried in her life, hair was one that remained most consistent:

> There's only one thing that I noticed that I stuck with my whole life and that is hair. So throughout high school, throughout college, I've always been that girl to do hair, everyone's hair. I did my coach's hair in high school. I was looking at my yearbook, I was like oh my goodness everybody's like "Oh, when you open your salon, let me be the first person to do your hair." At that time I never thought I would have a salon. That wasn't in my head to do, so it's funny how you put things in the universe and it comes back and you're doing it and you're like "What?"

Although Erica has tried several different occupations and career trajectories, hair has withstood her many changes to become her current path. She and others often traced their knowledge of hair care to childhood experiences with family or friend networks, beyond formalized institutions.

For example, while reflecting on her experiences as a mentor during the 2018 summer library program, Tonya explained her early learning as peripheral:

> I taught myself watching my mother do my step-sister's hair because my mother always did my hair and my step-sister's hair, and I always wanted to learn. So I would practice on my dolls or practice on my step-sister, and my mother never sat me down to teach me how to braid, but I would always, you know, sneak into the dining room or sneak, sneak into the living room when she was braiding and try to like watch her fingers and see how she twisted turns to make a braid.

Also, while reflecting on the summer 2018 library program, Vivian recalled another example of learning within hairstyling community networks and knowledge ecologies:

> My mom had a really good friend, and she was really good at braiding and she used to do my hair like every week, I would get my hair done, get my hair braided, twisted, whatever, any type, you know, an type of style, and at first I used to hate getting my hair done, but like I grew to love it, you know, I grew to "oh, you know, it looks nice, you know." I'm a girly girl, so I loved the braids, the bar rads, the beads and stuff. So I was so intrigued by her designs that I'm like, "you know what? I wanna try and do it on my Barbie doll." So,

> that's how that all came about.

Vivian's and Tonya's memories help to demonstrate the intergenerational transference of hair knowledge that begins early for many African American girls. Indeed, stories about grandmothers, mothers, sisters, and family friends modeling practices and supporting participation (directly or peripherally) were common for the women and girls.

Intergenerational stories highlight how knowledge is produced and circulated outside of formalized, institutional contexts of state recognition and credentialing. The inequities that credentialing can create have long been theorized (e.g. Illich 1971), but the line between what is considered "formal" knowledge and what is considered "informal" knowledge is not always clearly demarcated in these cosmetologists' own learning processes. For example, Monique articulates the fuzziness of such demarcations while describing her family's history of hairstyling and hair care:

> My grandmother was a hairstylist on both sides, my dad's mother and my mom's mother. My dad is a barber. So this was – I was born into this. My grandmother – my mom's – my maternal grandmother, she didn't have a license, but she was the neighborhood stylist. So everyone in the neighborhood would come to her house on Saturday because, you know, like they're very religious, no hair on Sunday, everything was done on Saturday.
>
> They would come to the house and everyone would have their hair done. It was a line of people. So seeing that, I always wanted to help or – I remember her, there's specific tools that we use with African American hair, because of the heat that, you know, the amount of heat that we need. I remember going in and like playing with the curling irons and clicking them.
>
> We actually teach that now here [in the cosmetology department]. And then my dad had him having his barbershop, you know, we were always there and then my – my dad's mother, she actually operated under a license and she worked in a beauty salon so, you know, walking in there was like a candy store for me [laughs] with the customers, and so that was where my interest started and then from there I was all – I picked that to trade up from my sisters. They were – they were the cooks and the, you know, my grandmother, she was always – she also made – she was like the neighborhood bakery in her house.
>
> So my sisters, they kind of took that part of her, me I took that you know, the barber hair part, and I became that person for my generation, with my cousins and you know, my siblings, and everyone, and people in my neighborhood, and then it just became a hobby, you know, something, well I thought it was a hobby and then later on that's when I decided to go and get my license for it.

The epistemic and material resources of hairstyling that Monique accessed were not only intergenerational but part of larger knowledge ecologies situated within African

American family life and community. The ability for her to move from hairstyling being a hobby to getting a license (i.e. formalized education) is supported by this ecology, which reveals pathways—to be taken or not—for translating those skills and knowledge into income and social networks.

Unlike Monique, Nichole did not often experience hairstyling as intergenerational familial knowledge, though she articulated the importance of it as such for many African American girls and women. While living with her grandmother, Nichole's early knowledge of hairstyling came from salons and peer interactions:

> But the thing about it was my grandmother, she didn't know how to do hair, so, I went to the hairdresser. And that's rare for like a Black child to go to the hairdresser all the time and get their hair done because usually your grandmother knows how to do hair and you sit in someone's kitchen and they are straightening your hair out or braiding it up but my grandmother didn't. So when I moved in with her, when I was like seven or eight, it was a girl down the street that knew how to braid, so she would braid my hair up and then when I got a little older, my grandmother started taking me to the hairdresser and I got Jheri curl, like it's [laughs] like back in the day.

Nichole's interactions with people in the salon were not trivial in her cosmetology education; in fact, quite the opposite. She explained how the connections she made in the salon as a child reappeared when she was a cosmetology student in a publicly funded program for young people and adults:

> But I didn't have like this real love or passion for it. I just knew that it came natural and easy for me so why not see if this is something that I want to do… And it was like for some reason, like people would gravitate to me I guess or I gravitated towards them and it was like a lot of the older women [in the program], so they kind of like, this always happens, they kind of like took me under their wing… and then the teacher… he was actually – well he was one of our teachers and that was my hairdresser growing up [laughs]... it was just so familiar to me… I didn't realize like I picked up on stuff quickly, but I didn't like the learning process of it [the program], I guess if you want to call it, but I would like pick up on it.

Nichole's ability to tap into this social network of intergenerational knowledge through salons and formal education helped her support her existing talents, even if they were not yet a passion. For Nichole and Monique, cosmetic businesses and public education are bolstered, interconnected, and a co-constituting part of cultural communities and knowledge ecologies.

Nichole's reflection on the learning process speaks to her pedagogical knowledge. The STEM-cosmetology program provided opportunities for the adults and students to engage people younger than themselves pedagogically. Some had not taken on this role so explicitly before. But, like African American beauticians of the past Monique and Nichole found pedagogical opportunities through hairstyling and cosmetology well before their contributions to the programs. Indeed, Monique had been teaching in the cosmetology department for over a decade while running her

own salon in the same city, authentically connecting public education with a local source of wealth generation.

While Monique went to school to be a licensed teacher before teaching high school cosmetology, Nichole did not despite having a long record of working in educational settings (e.g., a Head Start program, daycare, as a high school substitute, as a community college instructor, and more). In some cases, she was hired explicitly because of her cosmetology expertise and credentials: "like me being like the actual sub/building-sub/T.A. that just stayed in the [high school] cosmetology room and the principal knew it, the people at the human resources they created like this job for me." The STEM-cosmetology research project helped to reveal how it was just one instantiation of schooling being shaped by local African American women's hairstyling communities and knowledge ecologies.

Contributing to and being part of these communities and ecologies also influenced Nichole's and Monique's teaching preferences and approaches. Like many technical professions, including those in scientific and computing laboratories (Doing 2009; Turkle & Papert, 1990), learning by doing is an important part of hairstyling. Nichole extended this to her personal braiding pedagogy that prioritized starting where students are at and then building on their strengths: "I think that would be best, to just watch and see how comfortable they are at braiding and then direct them in how their hand posture is and how they're doing it so they can be better at the way they braid basically." Here, Nichole explained a way to support pedagogical differentiation by orienting her directions based on the students' existing knowledge and practices.

Monique also valued learning by doing and sought to prioritize hands-on experiences for students in the classroom. However, this sometimes conflicted with traditional pedagogical expectations:

> As far as teaching, we're taught to go through all the theory first of whatever you're teaching and then give them the clinical aspect of it. I believe when you work the opposite way, you get more from the student. You know, when you're starting the clinic first, show them that you can do this. You know, give them the terms, you know, you let the terms teach, "Okay, this is ammonium thioglycolate." You know, teach them what that ammonium thioglycolate is doing to the hair, and then they're more engaged. When they come and sit down, now it's not just the book of words. Now they understand they can connect whatever it is they learned over there to the theory that they're learning here now.

Not only does starting off with hands-on activities align with how many of the girls and women first learned how to work with hair in out-of-school epistemic networks of family, friends, and communities, but in Monique's case it also provided opportunities to rethink common assumptions about teaching and learning in the school system where she worked.

How do cosmetologists and cosmetology students conceptualize their knowledge in relation to STEM?

Out of all the STEM subjects, cosmetologists and students tended to identify their work most closely with science, specifically anatomy, physiology, and chemistry. While this might be expected due to the prevalence of science in cosmetology curriculum that aligns with state credentialing, the women and girls made these subjects their own in ways that converged and diverged with dominant science education. For example, Monique explained coloring and straightening hair as having clear convergences:

> Science of course, all over, we have, you know, the chemicals with the hair coloring, chemicals with hair perm, straightening hair, making the hair curly again, you know, the back and forth, what else... just changing the structure of the hair, that's all science. The anatomy – actually we're [her and her students] working on the anatomy now [laughs] of hair.

Throughout the interviews, the cosmetologists framed their scientific knowledge as not only important for supporting their clients' desires and wellbeing but also for communicating and educating their clients about hair. For example, Nichole described incorporating scientific literacies into her practice:

> It's just so important to kind of educate your client also on the science because it is a science. It's not like I mean I can create whatever it is I want with this hair, but this hair is made out of certain proteins and bonds and then your even down to your cells like they all work together and in a way which a lot of people that don't understand and don't educate themselves, don't realize and for me it's just amazing. Like how everything works together in turn and when you're doing something that's not right for your hair or your scalp, you'll see, you know what I am saying, like the condition.

For the professional cosmetologists, this knowledge was wrapped up with their styling practices, reputation, and profit. Indeed, Monique would not only explain to the research team that STEM topics should be connected to how they can help to improve salon businesses but also taught STEM topics through the lens of entrepreneurship in her classroom.

While Linda shared that she had a consistently positive view of science education and science's relationship to cosmetology, for Tonya, understanding that science and cosmetology are interconnected was not enough to maintain a positive relationship with science education: "I hate chemistry. I will say that, which is so weird 'cause I love hair coloring, and hair coloring is nothing but chemistry." But, Tonya explained that this was not always the case:

> Yes, when I was in elementary school... every day there was like really big science input like we used to do bird watching and different experiments and at that point I was doing a lot of experiments with science and I liked science but as I got older and more vocab and harder concepts I just kind of drifted away from it… because it wasn't as fun. I kind of lost that idea that science is

> everywhere around us and it's not really book work or just like, like science is everywhere. Hair coloring is science, birds watching is science, just like things that you kind of overlook every day that we do.

Here Tonya is constructing two types of science education, one that is supported by the *doing* of science, as it actively relates to her everyday life, and a second that is defined by learning science through knowing vocabulary and book work. The former creates an image of science as dynamic and creative, while the latter creates one of science as static and distanced from the day-to-day happenings of people's lives (Lachney, 2020).

When discussing science in the context of cosmetology, these two images often appeared together, as science was framed as both distinct from and part of the creativity of hairstyling. Indeed, what many of the cosmetologists and students valued about working with hair in the classroom or salon was that it allowed them to be creative and social. Sometimes a dichotomy between science and creativity was constructed, while other times cosmetology was a way to bring science and creativity together. Consider this quote by Tonya while she was reflecting on teaching cornrow braiding to younger children during the 2018 summer library program:

> I feel like some students they took more to be like, I don't wanna call it scientific, but like the scientific take to it, so the, like the rhythm and the patterns that you see in a braid, while other students they took more towards the creativity. They were able to look at something and replicate it as if it were a painting.

Even though she did not want to call hair braiding "scientific", this quote speaks to how hairstyling provides a space where creativity and science can intersect and connect. Indeed, Tonya also problematizes the dichotomy when describing why she became interested in cosmetology:

> There is so much science behind cosmetology, just put that out there, but there's different things that you can do with the hair, there's things with skin, make up and then you have, you know, your avant-garde. Like just, there's so much to cosmetology and I feel like even if you aren't someone who likes to do hair, there's so much design, there's so much creativity in cosmetology that if you are a creative being, you could find your niche. And even if you're a more of like a science, science/math person you can still find your niche within cosmetology.

While Tonya creates room for cosmetology-as-science and cosmetology-as-creativity to diverge, she also treats hairstyling as a meeting space for the two. It was this intermediary zone that the STEM-cosmetology programs sought to engage for rethinking STEM education, not only as hands-on but also full of creative opportunities for personal growth and expression, things that were already taken for granted in hairstyling and cosmetology more generally.

DISCUSSION AND CONCLUSION

In light of the answers to our two research questions above we now return to our guiding question: What are some ways that African American cosmetologists can help to reimagine STEM for Black girls and women? Before answering this question explicitly, we want to summarize our findings. This research demonstrated how African American women and girls who have expertise in cosmetology engage with a range of STEM disciplines (anatomy, physiology, and chemistry) concurrently in their work and pedagogy. Their teaching and learning preferences prioritized multidisciplinary, hands-on, learning by doing experiences. Both their STEM knowledge and their teaching and learning preferences were contextualized by family, friend, and community relationships. This leads us to make inferences about how African American cosmetologists may reimagine STEM for Black girls and women in three ways: 1) STEM as personal and situated; 2) STEM as a blend of public and community institutions and 3) STEM as community.

STEM as personal and situated - While STEM fields are often assumed to be distant, separate, and distinct from everyday life, the women and girls in this study showed how they can be situated and personal. Indeed, they discussed how STEM content is already part of their professional practices and that they negotiate this content in nuanced ways, including building rapport with clients and making salons profitable. Part of reimagining STEM can be about identifying how knowledge is utilized in the local community context in personally meaningful ways and then exploring those situated applications as generative sites for STEM education. Highlighting STEM as a personalized endeavor may help overcome negative stereotypes of its fields as technocratic, something Tonya clearly articulated.

STEM as a blend of public and community institutions - We also found that STEM in African American communities might occur at points of connection between public institutions (e.g., schools, libraries, city parks, etc.) and localized sources of wealth generation (e.g., salons, braiding shops, barbershops, etc.). Monique and Nichole were both active at the intersections of entrepreneurship and public education. Indeed, both public cosmetology education and African American cultural communities and knowledge ecologies were co-constituted in ways that broke down the illusion of schools as isolated and detached from the outside world. This was also accomplished by blurring boundaries between STEM fields and local communities. STEM fields and education can focus on how to support these connections in ways that innovate and benefit both: schools are able to contribute to local entrepreneurship, and local entrepreneurs are able to support schools, with STEM fields and professionals providing support for the flow of material and epistemic resources to move in both directions.

STEM as community - All the cosmetologists and students valued the ways that family and friends shaped and sustained their career trajectories. Indeed, hairstyling and salon practices are social and cultural activities where community life and creativity flourish. STEM professionals might seek to develop relationships of trust and care that build on social foundations of learning and producing knowledge in locally meaningful and relevant ways. STEM educators might reconsider who has relevant STEM expertise, using guest speaking events, for

example, not as opportunities to only bring in people from the academy and industry but also local community members whose knowledge intersects with STEM. These individuals can act as intermediate voices that allow students to understand how prevalent STEM is in local cultural contexts and practices, as well as the possibility for applying STEM knowledge in creative and expressive ways.

We conclude with a reminder from Collins (2009) about how Black women's knowledge production often appears in non-academic forms that can be sustained while being faced with patterns of suppression. With this and the above recommendations in mind, we reiterate the importance of framing these African American women as not only having unique pedagogical expertise that STEM educators can learn from but also as knowledge producers. Reflexively this is the case in this paper, but the data this paper reports on also emerged from a fundamental level of hairstyling knowledge that is deeply rooted and culturally situated within Black communities. Therefore, these STEM-cosmetology efforts to broaden participation should be recognized as just the latest example in a long legacy of Black hair care experts who have produced educational knowledge for social change.

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