Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls

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Biographical Sketch

Mercy Folashade Fash is a Ph.D. candidate in the Applied Science and Technology program at North Carolina A&T State University. Her goal is to leverage her technology management expertise, education, and talents to advance sustainability in engineering education, processes, and workforce development. With over 12 years of educational experience in teaching, research, and service, Mercy has made a meaningful impact in her field.

As a dedicated researcher, instructor, and mentor, Mercy has supported over 250 undergraduate and graduate students in the Departments of Applied Engineering Technology, Built Environment, and Chemistry within the College of Science and Technology at North Carolina A&T. She also served as an outstanding Affiliate of the Emerging Built Environment Women Center at North Carolina A & T. Her excellence is reflected in awards such as the 2022 NCA&T Graduate Rising Scholar Award, the CoST 2022 Graduate Rising Scholar Award, the 2022 Women in Science and Technology (WiST) Service Award, and the 2023 CoST Senior Graduate Teaching Assistant Award. Her mentorship has also empowered students to excel, with few earning top recognitions at conferences, including first place in science and mathematics education oral presentations at the 2023 Emerging Research Network (ERN) Conference in Washington, DC.

Mercy is grateful for the opportunity to contribute to filling gaps in women's career development literature. Her doctoral work focuses on understanding how gender and culturally responsive AEC-OST engagements can increase AEC career interests in African American middle school girls. Her goal is to contribute to addressing workforce shortages and enhancing female representation in AEC fields. Passionate about making a positive impact, Mercy is committed to inspiring, educating, and supporting the next generation of STEM professionals.

Dedication

To the participants of this study.

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Abstract

Although an increase in their participation could reduce workforce shortages and diversify innovations in the architecture, engineering, and construction (AEC) industry, African American women remain significantly underrepresented in male-dominated AEC careers. Furthermore, partly due to the lack of early and meaningful AEC exposure, African American girls tend to have low interests in AEC careers. AEC infused out-of-school time (OST) programs have been successful in increasing middle-school girls' AEC career self-efficacy and interests. However, there is limited understanding on how salient identities interact with learning experiences in AEC-infused OST learning environments to impact AEC career interests. The purpose of this research is to investigate how the salient identities of African American middle-school girls interact with learning experiences within a developed femalized AEC Kinesthetic Learning Model (fAEC-KLM) to impact AEC career interests. Adopting Lent's social cognitive career theory, the gender and culturally responsive fAEC-KLM is a five-day AEC-infused OST program that engaged 14 African American middle-school girls in bridge-building projects, a panel session with female and African American AEC undergraduates, interactions with female and African American AEC professionals, and success stories featuring female and African American AEC professionals. Using a mixed method approach, data from interviews, surveys, tests, and observations are analyzed to assess changes in AEC career knowledge, self-efficacy, outcome expectations, and interests.

Results show that the most effective fAEC-KLM components were lectures, bridge construction project, and peer interactions which improved AEC career knowledge, self-efficacy, and sense of belonging respectively. These in turn increased AEC career interests and three interest categories (active, passive, and null) are utilized to explain how varying fAEC-KLM

interactions contributed to three different levels of AEC career interests. The findings align with prior career development and intersectionality frameworks. Findings also fill a critical gap in career development literature by providing insights into AEC career interest development processes in African American middle school girls through OST programs while highlighting how gender and culturally responsive approaches foster interests. Insights and recommendations contribute to ongoing literature to support interventions and policies that foster more equitable representation in AEC careers, increase diversity in AEC innovations, and reduce workforce shortages.

CHAPTER 1

Introduction

1.1 Background

With its upward trend in the value of construction work put in place, the prevailing architecture, engineering, and construction (AEC) workforce shortage challenges present a crucial urgency for talented personnel who will contribute to AEC innovations and project outcomes (Engineering New-Record, 2024). Statista (2024) noted that the U.S. construction market was valued at nearly two trillion U.S. dollars in 2023 and is expected to reach over 2.2 trillion in 2027. Furthermore, the AEC industry is expected to grow with historical levels of federal infrastructure funding to include $383.4 billion over five years to surface transportation, an increase of 22% from current levels of spending (American Society for Engineering Education, 2022). These projections have increased the crucial need for talented personnel and innovations thus generating an intense focus on creative solutions to reduce prevailing workforce shortages.

Although African American women participation in the male-dominated architecture, engineering, and construction (AEC) workforce could reduce workforce shortages and increase diversity in innovations, they remain underrepresented in this workforce (Heydari et al., 2024; McKissak, 2023; Choi et al., 2018). The Hechinger report noted that while women of color made up 13% of the city's population, less than 1% of the construction jobs were awarded to women (Hechinger, 2024). Although women of color are 13.9% of the U.S. population (Catalyst, 2023), the Society for Women in Engineering (SWE, 2017) stated that women of color comprised less than 2% of engineering professionals. Furthermore, less than 4% of engineering bachelor's degrees were awarded to women of color (African American, Hispanic, and Native American)

and for African American women that percentage is diminishing (Yates & Rincon, 2017; Slaughter et al., 2015). Despite the gains in women representation in other STEM careers, women, especially African American women, remain underrepresented in AEC undergraduate programs and careers (Ofori-Boadu, 2018). This is attributed to several socialization barriers to include being a female, the lack of role models, as well as lack of early and meaningful exposure to AEC careers (Bauer, 2008; Heydari et al. 2024; McKissack, 2023; Ofori-Boadu et al., 2019). Therefore career interest development in African American girls towards male-dominated AEC careers is limited and YouScience (2024) revealed that black female students have 72% more aptitude than interest in Architecture and Construction. Ofori-Boadu et al. (2019) noted that middle-school girls associated their lack of AEC career interests with their discomfort with AEC learning experiences and competing career interests. This is not surprising as African American girls are less likely to identify with AEC careers due to the lack of counter spaces and role-models who are like them by gender and/or race (Society of Women in Engineering, 2017; Burgess, 2024).

Despite being 50.5% and 13.7% of the U.S. population respectively, women and African Americans remain underrepresented in AEC careers (U.S. Census Bureau, 2023; McKissack, 2023; Heydari et al. 2024; Ofori-Boadu et al., 2020). The National Council of Architectural Registration Boards (NCARB, 2021) noted that licensed female architects were 24% of the architect population. Furthermore, the 2020 racial and ethnic diversity improvement observed in architecture was attributed to increase in Asian and Hispanic populations only because the African American architect population remained low with little change over the past decade (NCARB, 2021). The American Society for Civil Engineering (ASCE, 2020) stated that women and African Americans were 14% and 6% of civil engineers respectively. Also, females made up

25% of the college demographic and the entire underrepresented minoritized population (to include African Americans) was 18.2% (ASCE, 2020). Only 11% of professionals in construction are women, and just 9% are Blacks (McKissack, 2023; YouScience, 2024b). Female underrepresentation in the construction industry is global as females comprise of 18.5%, 14%, 16.8%, and 11.3% of the industries in Australia, China, United Kingdom, and Sweden respectively (Heydari et al. 2024). Females also remain underrepresented in undergraduate construction programs in the United States (Ofori-Boadu et al., 2020). These statistics demonstrate how unlikely it is for African American girls to encounter AEC professionals who have similar female and African American characteristics which is crucial for AEC career interest development (SWE, 2017). Therefore low AEC career interest and participation persists in African American girls and women and is attributed to limited awareness and exposure, lack of role models, negative imagery, inequality in pay, racial profiling, gender profiling, environmental discouragement, old boys' network, and lack of respect for women (Patton et al., 2004; Heydari et al. 2024; Ofori-Boadu et al., 2020; Ofori-Boadu & Ofori-Boadu, 2022; SWE, 2017).

The AEC industry predates back to 400,000 B.C., when a man-made shelter was first discovered in Terra Amata, France (Jones, 2022). This shelter was constructed and used by humans during hunting seasons which demonstrates that AEC is older than many other industries. The development of shelter, transportation, and other built environment products have always been important to humans and justifies the importance of the AEC industry. Without this industry, it will be difficult for humans to accomplish what they have in this time and age (Harvey, 2022). Over time, this industry has advanced from utilizing mostly basic craftsman abilities to implementing complex processes to develop and maintain sophisticated structures.

This advancement has led to the need for various advanced AEC educational programs that prepare individuals to become AEC professionals with the competencies needed to support the design, development, maintenance, and demolition of 21st century-built environments (Harvey, 2022; Jones, 2022).

Regardless of these significant advances, the AEC industry is still plagued with persistent challenges including workforce shortages and the lack of gender and racial diversity (Ofori-Boadu et al., 2020). These challenges are of concern and received significant attention recently due to the huge demand for built environments and the impact of the AEC industry on people and societies with diverse backgrounds. Targeting the young minds of African American girls and engaging them in early and meaningful AEC-infused learning experiences in counter spaces such as all girls out of school time (OST) programs could increase their interests in AEC careers (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019; Patton et al., 2004; Safapour & Kermanshachi, 2020; Sinkele & Mupinga, 2011). Few researchers have provided early empirical evidence to demonstrate that AEC-infused OST programs impact AEC career interest in African American girls. However, little is empirically known of their salient identities and how interactions with learning experiences within AEC infused OST programs impact AEC career interest development in African American girls. This research aims to understand how identity interactions and learning experiences in a developed femalized AEC Kinesthetic Learning Model (fAEC-KLM) increase AEC career knowledge, self-efficacy, outcome expectations, and interests (KSOIs) in African American middle school girls.

1.2 Definitions

Definitions of the primary terms that serve as the foundational structure of this study are below:

- Career identity: is a structure of meanings where an individual connects their motivations, interests, and skills to suitable career roles (Meijers, 1998a).
- Career interests: are “expressions of personality” that guide vocational choices and behaviors (Nauta, 2007)
- Female: is used to recognize a woman or a girl (Yitah, 2009). The words female, girl, and woman are used interchangeably throughout this study.
- Femalized: a process fashioned to cater to the femininity of a girl or a woman.
- Identity: refers to the "kind of person" an individual aspires to be recognized as (Groen, 2017; Gee & Gee, 2000).
- Kinesthetic learning: is a hands-on type of learning where information is processed through touching or manipulating of materials for learning purposes (Murphy et al., 2004a).
- Knowledge: is justified true belief (Klein, 1971).
- Mixed method approach is a commonly used systematic research methodology where the researcher combines qualitative and quantitative research approaches to achieve a broad understanding and corroboration (Havard, 2022).
- Model: is a theoretical image of an object of study (Palvia et al., 2006).
- Outcome expectations: are the beliefs about the rewards, consequences, or outcomes for performing particular behaviors (Hackett, 2002).
- Self-efficacy: simply means having a “yes, I can do it” attitude, and it is a great tool that helps reflect an individual’s confidence in the ability to exert control over their motivation, behavior, and social environment (Bandura, 2006).

1.3 Statement of the Problem

Although improved participation could reduce AEC workforce shortages and diversify AEC innovations, African American women remain underrepresented in AEC careers. While wide gender gaps in STEM fields such as Chemistry no longer exist, women are still underrepresented in the male-dominated AEC industry (Association of University Women, 2024; Ofori-Boadu et al., 2020; National Coalition for Women and Girls, 2017). Considering that African American women were 13.9% of the 2021 U.S. population and projected to be 15.2% of the 2060 population, their less than 2% representation in engineering and low representations in the AEC industry is of concern (Catalyst, 2024; Society of Women in Engineering, 2017; McKissak, 2023). Their challenges include pay inequality, lack of skill development, reluctance to employ black females, inadequate training opportunities, and professor stereotyping (Broyles, 2009a; Patton et al., 2004a). Construction coverage (2024) noted that only about 11% of construction employees are women and (Nicholson, 2020) noted that 22% of American Institute of Architect licensed members are women. Civil Engineer Demographics and Statistics (2024) report also showed that African American civil engineers had the lowest average salary ($62,667) compared to other races. Although blacks were 13% of the U.S. population in 2022, they represented 6% of the U.S. construction workforce and 2% of licensed architects. Even in the broader STEM workforce domain, black workers were 9% of the 2021 U.S. STEM workforce, making them less than Hispanic (15%) and Asian (10%) workforce (NCSES Report, 2023). This report shows the 2022 median annual earnings of black STEM workers in the same broad STEM occupation type was $73,000, much lower than Asians ($107,000), Whites ($90,000), and Hispanic ($75,000).

In analyzing career exposure gaps (difference between aptitude and interest) in black students, YouScience (2024) found a 53% exposure gap towards architecture and construction

careers. This exposure gap was more significant in black girls who had 72% more aptitude for AEC careers than interest. This is not surprising as most African American girls are from families and communities that do not encourage girls to pursue AEC careers; while boys are encouraged to become AEC managers, girls are advised to pursue careers in health care and management (Furnham et al., 2002a; Inda et al., 2013a). Only a small percentage of girls hear about construction professions, and boys are twice as likely to see themselves working in engineering fields (Chavatzia, 2017). Girls avoid AEC because of women's complaints of isolation, harassment, bullying, sharing toilets with men, difficulty in finding personal protective equipment that fits properly, male oriented environments, as well as lack of flexibility, role models and job progression (Greed, 2000). There is a dire need for early introduction to AEC careers to provide more accurate insights and demolish misconceptions. Super (1953) describes the middle school age as an inquisitive age where minds are open making it an appropriate age for the engagement of AEC career-related activities to give girls a true sense of AEC careers and develop AEC career interests.

Career interests involve patterns of likes, dislikes, and indifferences regarding career-relevant activities and occupations (Hansen, 1984). Social cognitive theories indicate that career interests are influenced by person inputs such as predispositions, female and racial identities, as well as background, and environmental influences (Hackett & Byars, 1996a; Lent et al., 2000, 2017). Nevertheless, most career development literature are framed around male, white, and adult populations with limited inclusion of African American girls (Broyles, 2009b). Furthermore, literature on African American girls have focused on STEM career interests. Existing literature indicate that STEM Out of School time intervention programs have been found to increase African American middle school girls' AEC knowledge, self-efficacy and interests in male-

dominated STEM careers. In particular Ferro (2019) found that STEM intervention programs for underrepresented categories of students increased interest and choice through improvement in awareness, self-efficacy, outcome expectations, and task interests. However, because career and industry differences exist, the findings from non-AEC STEM research studies may not be fully transferable into AEC domains. While findings from existing pre-college STEM education and career interest development interventions have improved women's representation in disciplines such as Biology and Chemistry (Canning et al., 2017; Liben & Coyle, 2014; Lynch, 2020; Smith et al., 2017) African American women participation in AEC careers is still limited and African American girls' interest remain low. A review of literature revealed that most STEM career interest studies for girls from underrepresented populations have focused on high school and college educational phases (Ferro, 2019).

While there is an abundance of career-related interest development research studies focusing on disciplines such as STEM, nursing, and medicine (Bangcola, 2016; Brecker & Azzam, 2022; Ferro, 2019; Hudson, 2020), few have focused on the development of AEC career interests and self-efficacy in African American middle school girls (Luster-Teasley, 2016; Ofori-Boadu, 2018; Ofori-Boadu et al., 2019; Ofori-Boadu et al., 2020). These studies reported that AEC-infused OST programs improved AEC career-related knowledge, self-efficacy, persistence, and interests, in African American middle-school girls. However, they did not adopt a robust intersectionality lens that rigorously assessed interactions among gender, race, and AEC career interests. This presents a gap in career interest development theories as little is known of how to increase AEC career interests in African American middle school girls through AEC-infused OST interventions. Addressing this gap will inform the design and development of OST interventions as well as policies to support transitions of African American girls and women into

undergraduate AEC programs and the AEC workforce (Betz, 2002; Fouad et al., 2023; Lent et al., 2000). More empirical evidence is needed to inform and support the design, development, and implementation of early and targeted OST interventions to increase AEC career interests in African American girls. However, considering that initial evidence (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019) demonstrates that AEC-modified OST programs have been effective in increasing middle-school girls' AEC career interests, a femalized AEC-infused OST program is proposed and investigated to understand how salient identity interactions and learning experiences increase AEC career interests in African American middle school girls.

1.4 Purpose Statement

The primary purpose of this research is to investigate how the salient identities of African American middle-school girls interact with learning experiences within a developed femalized AEC Kinesthetic Learning Model (fAEC-KLM) to impact AEC career interests. This research study is informed by social cognitive career theory (SCCT) view on how career-related interests and choices develop over time (Lent et al., 2000a), career identity types (Holland, 1996a; Nauta, 2007), intersectionality (Crenshaw, 1989), and construction career interest development in minority middle-school girls (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019). Therefore, these foundational theories inform the development of the gender and culturally relevant AEC-infused OST kinesthetic learning intervention, fAEC-KLM, to impact and assess AEC career interest development in African American middle school girls.

1.5 Theoretical Framework

SCCT explains the processes associated with the development of academic and career interests, educational and career choices, and career and academic success (Hackett & Byars, 1996a; Lent et al., 2017b). Using Albert Bandura's general social cognitive theory, Robert W.

Lent, Steven D. Brown, and Gail Hackett developed a theory in 1994 that proposes three linked variables as the building blocks for career interest development and career decisions (Bandura, 1999a, 2002; Hackett & Byars, 1996a; Lent et al., 2000a). These variables are learning experiences, self-efficacy beliefs, and outcome expectations (Lent et al., 2000a).

This research adopts a streamlined framework to understand how career interests and choices develop, with focus on person inputs, learning experiences, self-efficacy, outcome expectations, and interests. Together, these factors contribute to shaping and advancing both academic and professional success. This theoretical framework is summarized in *Figure 1*.

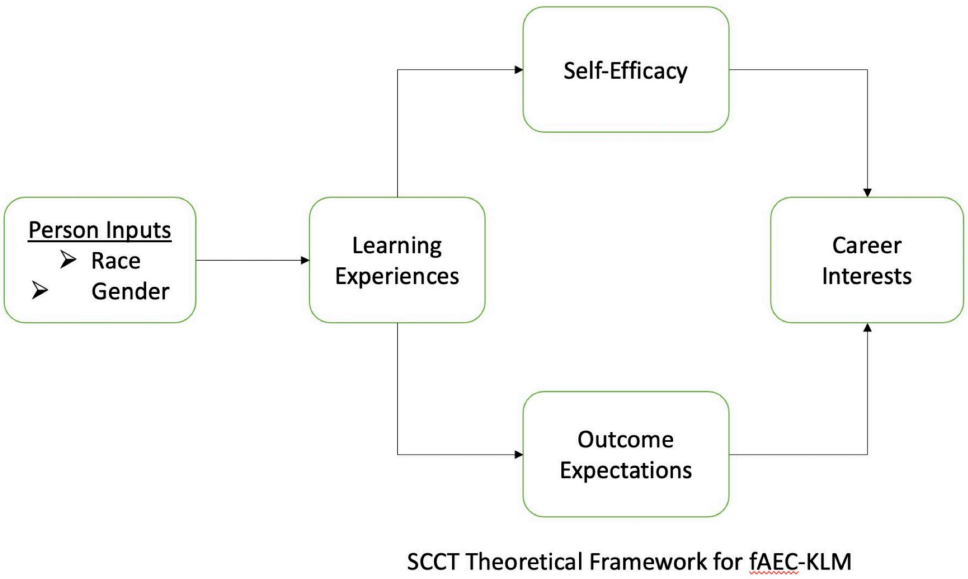


Figure 1. SCCT Theoretical Framework for fAEC-KLM

To examine how these variables operate within a gendered and racial framework, this study integrates Kimberlé Crenshaw's concept of intersectionality, which provides an essential perspective for understanding how overlapping identities, such as race and gender, uniquely shape individuals' experiences in education and career pathways (Crenshaw, 1989; Crenshaw, 1991; Crenshaw, 2013; Crenshaw, 2018). Crenshaw's intersectional lens is critical to identifying

and addressing the compounded barriers that African American girls face in exploring AEC careers, which are often influenced by both gendered and racialized expectations. By recognizing these intersectional factors, this research aims to develop a more inclusive SCCT framework that not only emphasizes the importance of self-efficacy, outcome expectations, and interest but also accounts for inequities that impact girls and women of color.

1.6 Significance of the Study

Designing OST learning environments to align with the unique identities and learning styles of underrepresented students is essential for fostering meaningful AEC career interest development (Hanover, 2017; Kita, 2021; Ofori-Boadu, 2018). School-aged children spend about eighty percent (80%) of their time out of school (Youth.Gov, 2022), and OST programs help keep them occupied while promoting positive youth development and safe spaces where they can explore their potential.

Recent research indicates that visual-kinesthetic learning experiences are preferred by girls who are likely to gain interest in AEC careers (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019; Ofori-Boadu et al., 2020). In many cases, students are expected to learn in passive environments, even though most lose focus within the first 15 minutes of class (Elissa, 2014b; Murphy et al., 2004b). Passive environment for learning can be tolerated or accepted in other disciplines, but not for AEC disciplines because it will be challenging to get a job without having any hands-on experience (Greeno & Engeström, 2014; McGlynn & Kozlowski, 2017; Nancy, 2019a). The movement of body parts to learn in the classroom cannot be over-emphasized. Movement is a motivator in class especially for students who get worn out from sitting at a spot in class (Boone, 2016a).

The proposed gender and culturally relevant fAEC-KLM adopts visual-kinesthetic instructional strategies for increasing AEC career-relevant KSOIs. Findings will inform the development of gender and culturally responsive OST kinesthetic learning models for improving AEC career interests in African American middle-school girls. Furthermore, findings may be transferable and contribute to increasing African American girls' interests in other male-dominated STEM careers. Findings will also contribute by bridging the gaps in women career development literature by providing insights into how African American girls develop interest towards male-dominated AEC careers. This could increase the persistence of African American girls into undergraduate AEC programs and the participation of African American women in AEC careers. In the long-term, an increase in the participation of African American women in AEC careers will reduce AEC workforce shortages and increase gender and racial diversity in the innovation of AEC products and services. It will also help inform the development of interventions and policies to support career interest development in African American middle school girls.

1.7 Research Questions and Research Design

The following research questions investigate how the salient identities of African American middle school girls interact with learning experiences within the proposed fAEC-KLM to impact AEC career interests:

RQ1. What are the most effective components of the fAEC-KLM in increasing AEC career interests?

RQ2. How do salient identities of African American middle school girls interact with learning experiences in the fAEC-KLM?

RQ3. To what extent does the fAEC-KLM impact AEC career knowledge, self-efficacy, outcome expectations, and interests in African American middle school girls?

These questions lay the base for the central hypothesis of this study, which is that the fAEC-KLM is an effective tool in understanding how salient identities interact with learning experiences to impact AEC knowledge, self-efficacy, outcome expectations, and interests (KSOIs). A mixed method approach, incorporating both qualitative and quantitative analyses, is employed to address these questions (Rieger, 2019; Singh & Estefan, 2018). This approach is particularly effective when existing theories are limited in explaining a process within a specific population (Emerald, 2022; George, 2022; Havard, 2022; Schoonenboom & Johnson, 2017).

This research uses purposive sampling to select African American middle school girls with strong interests in math, art, and science (Ofori-Boadu et al., 2020). Guided by the social cognitive career theory of career development (Lent et al., 2000a), Crenshaw's intersectionality theory, and practical AEC-infused OST principles, the study aims to foster AEC career interest in African American middle school girls in an all-female and African American counterspace and learning environment (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019).

The proposed gender and culturally relevant fAEC-KLM is a five-day AEC-infused OST program designed to engage African American girls in an interactive hands-on bridge-building project, female and African American AEC undergraduate panel sessions, female and African American AEC professional role-model interactions, and success stories of female and African American professionals in an all-female and African American counterspace and learning environment. Salient learning experiences, identity interactions, and impacts of the developed model were analyzed to evaluate changes in AEC career interest development (Gee & Gee, 2000; Mills et al., 2006; Ofori-Boadu, 2018; Ofori-Boadu et al., 2019).

A mixed-method approach involved the analysis of qualitative and quantitative data (Kaiser, 2009; Pace, 2005; Resnik, 2018). To increase the validity of results obtained from data collection and analysis, methodological triangulation involved interviews, surveys, tests, and observations. The importance of having methodological triangulation is to enhance validity, create a more in-depth picture of a research problem, and interrogate different ways of understanding a research problem (Nightingale, 2009; Nightingale, 2020; Thurmond, 2001; Wilson, 2014). Pre-intervention interviews, surveys, and tests were administered before participants engaged with the fAEC-KLM (Kontogianni et al., 2020; Pooja et al., 2021; Vansant-Webb & Polychronis, 2016; Yates & Leggett, 2016). Following fAEC-KLM interactions, post-intervention interviews, surveys, and tests were conducted to assess any changes in AEC career interest-related responses. All activities within the fAEC-KLM were video recorded for observation.

Interviews have open-ended questions to solicit more personal and detailed responses from the participants. Follow-up questions were asked for deeper insights into participants' experiences and perspectives (Kontogianni et al., 2020; Pooja et al., 2021; Vansant-Webb & Polychronis, 2016; Yates & Leggett, 2016). Interviews were conducted using constructivist interviewing and critical incident technique, with each interview analyzed to refine questions and guide discussions in subsequent interviews (Bradley, 2022; Carlone & Johnson, 2007; Vansant-Webb & Polychronis, 2016). Data analysis involved coding and constant comparative analysis using the NVIVO qualitative analysis software (Lewis, 2015; Mills et al., 2006). The comparison of pre- and post-interviews increased understanding of identity interactions with learning experiences, and model impacts on AEC career KSOIs.

Surveys have demographic, ranking, open-ended, and Likert-scale questions. With demographic items, participants provided data that increased understanding of their backgrounds and salient identities. With ranking items, participants ranked model components that effectively increase their AEC career interests. With open-ended questions, participants shared experiences and perceptions on AEC-related concepts (Kaiser, 2009; Pace, 2005; Resnik, 2018). With the Likert-scale section, which requires indicating a level of agreement with specific AEC career interest-related statements, participants ranked their own learning experiences, knowledge, self-efficacy, outcome expectations, and interests. Quantitative survey data were analyzed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel. The comparison of pre- and post-surveys increased understanding of identity interactions with learning experiences, and model impacts on AEC career KSOIs (Admin, 2017a, 2017b; Alchemer, 2021a; Boost, 2019a; Silverlake, 2021a).

The tests included multiple-choice questions designed to assess AEC career knowledge pre- and post-intervention. Quantitative data from these tests were analyzed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. Paired-samples t-tests (alpha = 0.05, 95% confidence level) were conducted to compare pre- and post-intervention results, providing insights into the intervention's impact on AEC career knowledge (Admin, 2017a, 2017b; Alchemer, 2021a; Boost, 2019a; Silverlake, 2021a).

Real-time observations of participants' interactions during the fAEC-KLM model implementation were recorded through notetaking and video recording. This data captured participants' conversations, actions, and attitudes, providing insights into their engagement with the model's learning experiences. Observational data was analyzed using the Virtual Timing Device (VTD), Statistical Package for the Social Sciences (SPSS), and Microsoft Excel (Admin,

2017; Boost, 2019; Chouhurg, 2015; Prasanna, 2022). This analysis deepened the understanding of how salient identities influence learning experiences within the fAEC-KLM.

Recorded observations are evaluated through a pre-designed template in the Virtual Timing Device (VTD), with career interest categories based on career-relevant self-attributes or self-meanings highlighted by participants relating these to the activities carried out within the fAEC-KLM. This approach supports the identification of key career interest categories, allowing us to examine how participants' career self-attributes influence their interactions with AEC-related learning content and environments.

Findings from data analysis are expected to show how this model supports identity interactions and learning experiences, as well as impacts AEC career knowledge, self-efficacy, outcome expectations, and interests. Insights will focus on the extent of these impacts, as well as female and African American identity interactions. Findings contribute to career interest development strategies, with potential applications in nationwide OST programs aiming to foster AEC career interests among African American middle-school girls. Findings will fill gaps in career development theories as well as inform the replication of this model in national OST programs to increase AEC career interests in African American middle-school girls. Furthermore, insights inform the design and development of appropriate policies to increase AEC career interest and representation in the AEC workforce. In the long term, this could increase African American women’s participation in AEC careers, increase diversity in AEC innovations, and reduce AEC workforce shortages.

1.8 Scope of the Study

This research study aims to investigate how the salient identities of African American middle-school girls interact with learning experiences within a developed fAEC-KLM to impact

AEC career knowledge, self-efficacy, outcome expectations, and interests (KSOIs). The five-day model was implemented in the summer of 2023 on the campus of North Carolina Agricultural and Technical State University, and engaged16 African American middle school girls from Guilford County, North Carolina. Guided by SCCT, purposive sampling was used to recruit participants with specific characteristics:

1) African American – as a person input, race is essential in identity and career interest development as it affects how a person is perceived in society and influences career interests and participation (Acker, 2006; Alvarez, 2011; McCluney et al., 2018; Nikkhah Manesh, 2020);

2) Females – gender also as a person input is crucial as it affects how a person is perceived in society and influences career interests and participation (Khajehpour et al., 2011; Lannin et al., 2023; Ozdenerol, 2021).

3) Middle-School status – Engaging middle school girls as participants in an effort to understand their learning experiences is essential for this study. Research shows that at this stage many girls learn behaviors, social interactions, self-direction, and persistence, which makes it a vital career interest development stage (Antoniou et al., 2016; Nauta, 2007; Savickas, 2001).

4) Enrollment in Guilford County middle school – This provides a centralized region where participants will have to be physically present to interact with the fAEC-KLM, and where data can be gathered. Also, it provides one unique baseline characteristic concerning environmental influences that is common to all research participants.

5) Predisposition to Math, Art, and Science – this is to ensure that participants have the basic perquisite learning experiences, interests and abilities that predict strong potential to develop AEC career interests(Ferrare & Hora, 2016; Hornig, 1984; Lock et al., 2013; Ofori-Boadu et al., 2020).

1.9 Limitations of Study

A primary limitation of this study is its small sample size of African American middle school girls from a single U.S. County, which may narrow the diversity of identities represented and limit the generalizability of findings to other regions. However, the study offers an intervention and research model that can be replicated in other U.S. areas, allowing educators to adapt the model with modifications to fit their specific regions and populations.

1.10 Chapter Summary

This document is divided into five (5) chapters. Chapter 1 briefly introduces the background, definitions, problem, purpose, research questions, methodology, significance, scope, and limitations of the study. This chapter presents the research questions guiding this study are presented in this chapter, along with the scope and the processes involved in carrying it out.

Chapter 2 provides a detailed literature review of foundational theories that explain career interest development, career identity development, characterize career interest development experiences of African American middle school girls, describes kinesthetic learning and existing studies of middle school girls' experiences in AEC-infused program, different theories on career development, emphasizing on Holland's theory of career identity, the social cognitive career theory (SCCT), and Ofori-Boadu's career interest development in middle-school girls, and nascent professional identity development in undergraduate AEC women. Insight is given into the challenges associated with AEC professions and how this research can contribute to resolving these challenges. Also, an in-depth explanation of the types of learning there are and why kinesthetic learning was selected for this study.

In Chapter 3, an overview of the research methodology is presented. The rationale for choosing methods to respond to the research questions is explained. Also given is a detailed

description of the characteristics of the research participants for this study, as well as the data collection and analytical procedures and tools. A detailed explanation and justification of fAEC-KLM components is provided. Lastly, the validity of methods and the limitations of the study are provided.

Chapter 4 presents detailed results on the learning experiences and impact of the fAEC-KLM. Results obtained from the analysis of all data gathered throughout this study are presented, discussing in detail what each result means and how it responds to the research questions. The success determinant of the study and a research summary linking the research questions to the activities within the model are also presented.

In Chapter 5, to conclude this study, key findings, implications, areas of future work, and concluding remarks are discussed.

CHAPTER 2

Literature Review

2.1 Introduction

The primary purpose of this research is to investigate how the salient identities of African American middle-school girls interact with learning experiences within a developed femalized AEC Kinesthetic Learning Model (fAEC-KLM) to impact AEC career interests. Career interest development theories recognize self-efficacy and student potential as critical pathways that enable increasing career interests (Bandura, 1999b). Developing early career interests is an important pathway to career identity development and is essential to future career productivity and satisfaction (Serpe & Stryker, 2011). Extensive research has been conducted to emphasize the importance of early career awareness and identify the optimal age of introducing students to core strengths that shape their career trajectories. Greeno & Engestrom (2014) argue that no student is a blank slate, but each student has a measurable knowledge of fundamental subjects. Their knowledge and understanding are largely shaped by early lived experiences, including observations and conversations within their environments (Simmons & Simmons, 2012).

Environmental, societal, and intersectional experiences are known to greatly influence adolescent's career decisions (Lent et al, 2017; Crenshaw, 1989; Ofori-Boadu et al., 2019). It is well-documented that some experiences negatively affect career interest development processes in underrepresented minorities to include African American girls (Burgess, 2024). This leads to misconceptions about masculine and male-dominated careers. For instance, society paints the Architecture, Engineering, and Construction (AEC) professions as "male and white professions," implying that only males and whites can survive, excel, and make a good living from these professions (Betz & Voyten, 1997a; Patton et al., 2004a; McKissak, 2023). These notions must

be tackled and corrected so African American girls know that they can succeed in male-dominated professions. Furthermore, this will increase gender diversity in these professions and reduce global workforce shortages.

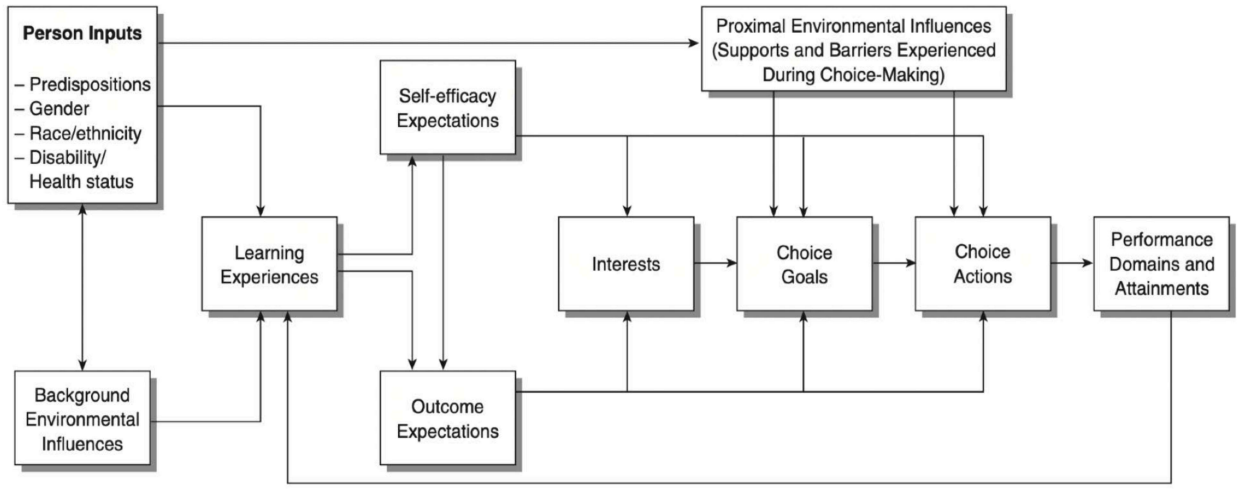
Pursuing this research is critical and requires a deep probe into existing career development literature to provide an informed understanding of the problem and the potential solutions with particular focus on this understudied demographic. This literature review provides a framework to contextualize this study while revealing the gaps in existing career development literature that motivates the implementation of this dissertation. While few OST programs have contributed to AEC career interest development in African American middle-school girls, they do not highlight the gender and race intersectionality concept (Crenshaw, 1989), and little is empirically known about how their salient identities interact with their learning experiences to influence AEC career interest development.

This chapter discusses the social cognitive career theory (SCCT), other career identity theories, kinesthetic learning, underrepresentation of African American women in AEC professions, AEC career interests in African American middle-school girls, AEC-infused OST programs, and gaps in existing literature on AEC career interest development in African American middle-school girls. It emphasizes the urgency of understanding this problem and developing effective interventions. The definitions of key concepts that frame this study are provided to capture dynamic model interactions that can improve AEC career interests in African American middle school girls. The chapter concludes with a brief overview of the projected outcomes of this research study.

2.2 Social Cognitive Career Theory (SCCT)

The SCCT (Hackett & Byars, 1996; Lent et al., 2017) explains the processes involved in developing academic and career interests, making educational and career choices, and obtaining career and academic success. In particular, SCCT highlights the need to offer females the same attention and opportunities as males. Using Albert Bandura's general social cognitive theory, Robert W. Lent, Steven D. Brown, and Gail Hackett developed a theory in 1994 that proposes three linked variables as the building blocks for SCCT (Bandura, 2002; Hackett & Byars, 1996a; Lent et al., 2000b). These variables are self-efficacy beliefs, outcome expectations, and personal goals (Lent et al., 2000a). The SCCT forms the foundation of this research, which investigates how the salient identities of African American middle school girls interact with learning experiences within a developed fAEC-KLM to impact knowledge, self-efficacy, outcome expectations, and interests. These are all critical aspects associated with the development of AEC career interests.

Considering that this research aims to apply SCCT to understanding AEC career interest development in African American middle-school girls, a proper understanding of the different components of the SCCT theoretical model, shown in *Figures 1 and 2*, is explained to get deep insights into this process.



SOURCE: Adapted from Lent, R. W., Brown, S. D. and Hackett, G. 1994. "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance" [Monograph]. *Journal of Vocational Behavior* 45:79-122.

Figure 2. Social Cognitive Career Theory (SCCT)

Person inputs refer to a person's identity in the form of gender, race/ethnicity, disability/health status, and other predispositions and factors that affect career interests. In male-dominated careers such as AEC careers, gender inputs are important because inequality is evident and men are given higher precedence over women, and this limits career opportunities for women (Hackett & Byars, 1996b). Similarly, many careers have racial or ethnic preferences for certain roles (Acker, 2006; McCluney et al., 2018; Ozdenerol, 2021), which can restrict individuals' career options.

Identity as a form of person input is key in developing career interests and making career decisions. In this context, identity refers to the "kind of person" an individual aspires to be recognized as, encompassing several types: natural identity (inherent, genetic identity related to "who you are"), institutional identity (identity granted by institutions, such as a reverend in a church), discourse identity (character traits acknowledged by others, like being pragmatic or cheerful), and affinity identity (identity formed through group affiliations) These forms of

identity are interconnected, and individuals often possess multiple identities. Early awareness of one's identity can facilitate early career-related decisions (Gee & Gee, 2000).

Batool and Ghayas (2020) emphasize that career identity formation improves the persistence of students to become professionals in different careers, which means that early opportunities and educational curriculums should be created for students early enough in their educational processes to help them understand their identities and how their identities can affect future career-related decisions. It is essential to expose young individuals, especially young African American girls, to early career-relevant education so that physical attributes and social barriers do not restrict their career goals toward male-dominated careers such as AEC careers. According to Vanderpool (2019), most women who chose careers in Architecture, Engineering, and Construction (AEC) suggest that extensive exposure to AEC experiences greatly impacts their confidence to pursue these careers. Understanding the role(s) of person inputs with a focus on how gender (female) and race (African American) intersections influence career interests is the focus of this study. Implementing female and race-based learning structures in an OST-AEC model will help understand the impacts on participants' learning experiences and career interest development.

Environmental influence impacts career decisions as students may or may not want to pursue Architecture, Engineering, and Construction (AEC) careers due to previous experiences encountered in their environment at certain stages of their lives. Environmental influences may be associated with politics, religion, and other societal occurrences that manipulate or affect career interest decisions (Lent et al., 2000a). For instance, a girl from a religious family may believe that AEC professions are for men and that women should pursue medicine, nursing, or hospitality as women are better suited for care-giving professions. She will make a career

decision based on her religious beliefs, and not on her strengths and passions. On the other hand, a girl with similar abilities from a non-religious family who has been taught early in life, that irrespective of environmental influences, she can pursue any profession she wants to, will have a different understanding of how to make career decisions and will make a better-fit career decision based on her strengths and passions (Acker, 2006; Inda et al., 2013b; Patton et al., 2004a).

Many students learn more effectively through hands-on activities and visual experiences rather than auditory instruction, making it essential that their educational environments provide kinesthetic learning experiences. Nevertheless, it is a fact that only a small portion of females are encouraged to pursue careers in the AEC profession as certain environmental factors limit the opportunities for AEC career awareness and interest development in females (Barnes et al., 2005). For example, some trainers or tutors believe in giving females easier and less complicated tasks, with the understanding that women are fragile and cannot handle specific tasks or activities as well as their male counterparts. These environmental conditions to include gender stereotyping, biases, and discrimination have influenced some professional institutions that prefer males for specific professional roles (Assari & Caldwell, 2018; Brown & Bigler, 2004; Masinga et al., 2020). Exposing African American middle school girls to the fAEC-KLM will serve as a platform to debunk perceptions instilled in them by environmental influences on career interests and decisions.

Learning experiences influenced by person inputs and environmental influences. Without early career-relevant learning experiences and encouragement that support career decision-making, students may struggle to select courses or programs and opportunities that support career success. Lock et al. (2013b) note that in STEM careers, factors such as

performance, competence, and recognition of abilities play crucial roles in shaping career interests and decisions. Furthermore, suggesting that compliments from teachers, parents, and friends provide the support and courage to pursue best-fit careers. Learning experiences and exposure, including excursions, hands-on projects, competitions, and books, play influential roles in helping students develop career interests and make career decisions (Graven & Heyd-Metzuyanim, 2019).

Personal accomplishments are also categorized under learning experiences, as they are also a determinant for career decisions. For example, a high-school girl who always wins STEM competitions will have her accomplishments recognized and will likely enter a STEM profession. In contrast, a girl who frequently receives recognition for her artistic or design abilities is more likely to pursue a career in architecture or construction (Hackett & Byars, 1996b). Verbal persuasion is an essential component of effective learning experiences. A girl with a particular skill or passion might not be convinced that she should pursue a career related to that specific skill. However, with recognitions and verbal persuasions from friends, parents, or teachers, she can be convinced to pursue a career related to her skills and accomplishments (Lent et al., 2000a).

Self-efficacy belief cannot be overemphasized. It depends on a person's achievements, as well as mental, physiological, emotional states, and vicarious experiences. Self-efficacy is a personal belief that one has the capabilities to perform certain actions (Bandura, 2006). Self-efficacy can change at any time and is domain specific. Consequently, a person can have strong beliefs to overcome hurdles and attain success in an engineering profession but may not have the same beliefs for an accounting profession. Major career decisions depend on self-efficacy which determines is related to academic excellence (Schunk, 1991). A task that an individual believes

she can accomplish and is determined to put in her best efforts to achieve is likely to result in success.

Significant research has been conducted to understand the relationship between self-efficacy and career interests as they are closely related. STEM women can eradicate work shortages and lack of diversity in STEM professions if they have strong beliefs in their capacity to meet or exceed expectations of them in their professional fields. (Carlone & Johnson, 2007). Exposure of women to learning experiences that build self-confidence in AEC career success will strengthen career interests, increase diversity, and reduce AEC workforce shortages (Hornig, 1984; Rodriguez, 1993; Yi, 2019). Self-efficacy and learning experiences influence outcome expectations (Lent et al., 1994; Lent et al., 2017).

Outcome expectations are the believed results or consequences of performing activities (Hackett & Byars, 1996a; Lent et al., 2017b). Individuals pursuing career success understand that putting great effort into related courses and passions leads to the expected outcomes, such as financial stability and improved living standards. For example, an individual who becomes an Architect might decide to work harder and attain certifications and a broader portfolio to make more money than her peers. The SCCT perceives that efforts, persistence, and engagement in activities are determined partly by a person's self-efficacy beliefs and outcome expectations. Self-efficacy is better used to predict career decisions, while outcome expectations predict exploration intentions (Betz & Voyten, 1997a). Although self-efficacy and outcome expectations may be interrelated, there is a significant difference between both as a correct performance does not necessarily lead to a desired outcome. To ensure success or avoid struggles, many individuals choose familiar tasks or careers that promise positive outcomes. Lent et al. (2017), highlight the connection between outcome expectations, learning experiences, and self-efficacy, suggesting

these elements are interdependent. Outcome expectations rely on self-efficacy (confidence in one's ability to complete a task) and learning experiences (knowledge gained that supports task completion). Alongside self-efficacy and learning experiences, the development of career interests plays a crucial role in career choices and success.

Interests in career-relevant activities or tasks grows from self-efficacy and outcome expectations. From the theory proposed by Hackett & Byars (1996b), individuals are likely to develop interest in activities that they have strong beliefs that they can accomplish (self-efficacy) and will produce positive outcomes. Positive outcomes encourage individuals to increase involvement in certain career-related activities, eventually resulting in career commitment. As stated in the SCCT, interests thrive in areas where an individual possesses talents and is exposed to environments through direct, vicarious, or persuasive experiences that can help the individual develop self-efficacy beliefs and positive outcome expectations. Interest in certain activities mostly begins in adolescence (Lock et al., 2013b), when individuals become aware of profound interests that develop into career goals. Interests in specific careers are developed by the person's learning experiences and/or self-efficacy. These interests in certain activities or careers further help the individual choose and set personal goals to achieve success in these careers.

In summary, this research study focuses on using gender and race person inputs as a core in developing learning experiences that interact with and increase AEC-related knowledge, self-efficacy, and outcome expectations, using the SCCT concepts.

2.3 Other Career Development Theories

Discussing career interests naturally involves exploring career identity and career development theories. Career identity development refers to the process through which individuals align their interests, motivation, and skills with suitable career roles, creating a

meaningful personal framework (Meijers, 1998b). Career development theories highlight how individuals' identities, interests, attributes, competencies, and skills can influence career paths. Identity is a concept that combines the secluded or personal world with external space of cultural forms and social relations (Groen, 2017). Santisi et al. (2018) argue that career interest is not tied to specific job roles or workplaces but is shaped by a series of work-related experiences that define an individual's career identity. The study of career interest dates to the 1900s, starting with Frank Parson's theories, and other theories that were developed afterward. For the past 75 years, career development theories have progressed steadily with the work of several theorists. Frank Parson's (1920s) trait and factor theory, matched personal traits to occupations; Holland's (1980s) psychological personality types theory matched persons to work environment; Bandura's (Self-efficacy-1970) theory, highlighted self-efficacy; Super's (1950) theory focused on developmental self-concept over life span; Krumboltz's (1976) Social learning theory highlighted individual development and experiences; Ann Roe's (1969) "needs" theory focused on environmental and genetic factors; Linda Gottfredson's (1981) theory explained circumscription and compromise; while Tiedeman and Miller's (1961) theory presented a decision-making model. For the purpose of this research, Holland's (1980) career identity and Bandura's self-efficacy theories are utilized to frame relationships between identities, learning experiences, interests and other career-related outcomes.

2.3.1 Holland's (1980's) Career Identity Theory

Holland's theory of career identity delves into the personality and behavioral styles that influence career interests and choice development. This theory matches six identity types with related occupations. They are: (1) Realistic (work with hands, machines, tools, active, practical, adventurous) with related occupations (construction, farming, architecture, mail carrier, truck

driving); (2) Investigative (thought, analytical approaches, explore, knowledge, ideas, not social) with related occupations (biologist, chemist, dentist, programmer, veterinarian); (3) Artistic (literary, musical, artistic activities, emotional, creative, open) with related occupations (artist, musician, poet, interior designer, writer); (4) Social (train, inform, educate, help, supportive, avoid technical skills, empathy) with related occupations (social work, counseling, police officer, LPN); (5) Enterprising (verbally skilled, persuasive, direct, leader, dominant) with related occupations (lawyer, business executive, politician, TV producer); Conventional (rules and routines, provide order or direct structure, great self-control, respect power and status, punctual, orderly) with related occupations (bank teller, clerk typist, cashier, data entry) (Holland, 1962; Holland, 1996b). According to Holland's theory, an individual falls into at least three of these vocational types but mostly leans towards the most dominant type (Antoniou et al., 2016b).

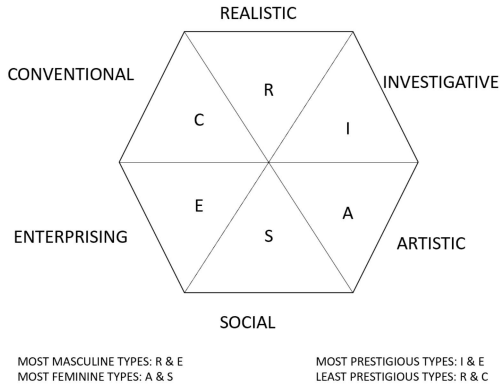


Figure 3. Holland's representation of different career identity types (Nauta, 2007).

This theory summarizes the characteristics that individuals within these career types possess. Individual career-relevant characteristics include occupational interest which is an expression of personality. Members of an occupational group have similar personalities and people within each group respond to situations and problems similarly. Occupational achievement, stability, and satisfaction depends on largely congruence between an individual's

personality and job environment (Margaret, 2010). Howard's theory provides an easy guide to place interests with related occupations. However, one shortcoming of this theory is that it does not provide detailed insights or guidance for educational advisement and career counseling. It lists the career characteristics and occupations that can fall under these characteristics but fails to provide guidance on how adviser could direct students through understanding these characteristics and related occupations that perfectly fit align with their interests and identities.

2.3.2 Bandura (Self-efficacy-1970's) Decision Theory

Tapping into these career interest development theories paves the way for exploring career interests in young minds. Career interests through exposure and training have a finite trajectory with self-efficacy. Self-efficacy is the "I can do it" attitude that an individual possesses (Ofori-Boadu et al., 2019). Bandura is famous for self-efficacy perspectives, which highlight the belief in one's capabilities to achieve attainments through organized and executable processes (Bandura, 1994). Oftentimes, self-efficacy is confused with self-esteem as self-esteem is a measure of a person's worth, and self-efficacy is the self-belief of a person to achieve a goal (Betz & Voyten, 1997b). Self-efficacy plays a vital role in an individual's motivational process, which can be affected by environmental and personal experiences that can influence an individual's interests, choices, achievement, effort, and persistence (Farmer & Tierney, 2017; Gallagher, 2012).

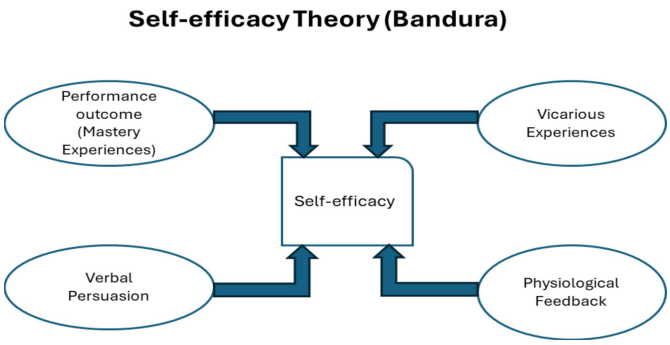


Figure 4. Fundamental Keys of Self-Efficacy (Bandura, 1994; Bandura, 2006)

Figure 4 illustrates the key components (Bandura, 1994; Bandura, 2006) or influencers of self-efficacy with the components described below:

Mastery Experiences: These are personal accomplishments that directly impact self-efficacy. When individuals successfully complete tasks, they gain confidence in their abilities, reinforcing their belief in their capacity to succeed in similar future tasks. Successful experiences boost confidence in abilities, while failures may decrease it. Mastery experiences are the most powerful influence on self-efficacy as they involve firsthand evidence of one's capabilities.

Vicarious Experiences: This refers to observing others perform tasks successfully, which can increase an individual's self-efficacy by demonstrating that success is achievable. Observing others successfully perform a task can strengthen belief in one's own ability to achieve similar outcomes. Seeing peers or mentors succeed, especially in situations perceived as comparable to one's own, can raise self-efficacy by creating relatable role models.

Verbal Persuasion: This refers to positive encouragements or constructive feedback from others that can enhance an individual's belief in their own abilities. Positive reinforcement, such as receiving praise or encouragement from teachers, family, or peers, can bolster belief in one's abilities, while negative feedback can undermine confidence.

Physiological Feedback: refers to the physical and emotional responses an individual experiences when facing a task, which can influence their self-efficacy. The physical and emotional responses one experiences in relation to a task—such as anxiety, stress, or excitement—can affect self-efficacy. Positive emotions can enhance self-belief, while high levels of stress or anxiety may lower it, influencing performance and motivation.

Several researchers (Hackett & Betz, 1981; Lent et al., 2017; Ofori-Boadu et al., 2020; Phuong, 2018) have shown interactions between learning experiences, self-efficacy, and career interests. Girls' exposure to specific career-related tasks increases the awareness of their abilities and capabilities to complete those tasks. Typically, girls with limited knowledge of their capabilities are scared to try new activities outside their comfort zones. With constant encouragement and exposure to career-related activities, girls are likely to develop self-confidence in accomplishing said tasks (Scholz et al., 2002). Young African American girls are often led to believe that AEC careers are unsuitable for women. They are discouraged from viewing these fields as spaces where they can succeed, outperform male peers, or build financially stable careers (Felder, 2014b). These factors have discouraged many young women, particularly African American girls, from pursuing careers in AEC (Meijers, 1998b). However, these barriers can be reduced through early, tailored AEC-focused OST programs with gender and culturally relevant modifications that aim at increasing self-efficacy and career interests in African American middle school girls. Such initiatives help them recognize their strengths and interests, build career identities, and consider future pathways aligned with their passions (Valamis, 2021). Middle school is a pivotal age for career exploration, as girls are often more open to learning, and cultivating career interests (Jordyn, 2021; Ofori-Boadu, 2018).

2.3.3 Crenshaw's Intersectionality Theory

Implementing a gender and race focused study without making any reference to this theory leaves a lot unsaid. This theory provides a critical framework for understanding how different forms of discrimination and disadvantage intersect and overlap lived experiences (Byars-Winston & Rogers, 2019; Charleston et al., 2014; Kimberly, 1989). It argues that the lived experiences of any girl of color are shaped by the overlapping systems of race and gender. This indicates that African American girls need to work twice as hard as their counterparts and also receive constant exposure to relatable experiences that can foster career pathways for them while also achieving efficient preparedness to overcome racial and gendered challenges they will encounter. Gender difference and inequalities are not natural or fixed, but actively created and recreated through mundane social practices that render gender distinctive and hierarchical which causes the need for an intersectional approach to capture how multiple dimensions of difference like race and gender interweave to construct distinctive systems of gender oppression and privilege (Fenstermaker & West, 2013). Through the fAEC-KLM, the research participants (RPs) are exposed to challenges and success stories of professional African American AEC women and strategies for success in AEC fields which can impact their interests in AEC careers.

2.3.4 Gottfredson's Circumscription and Compromise Theory

This theory proposes that career aspirations become progressively more circumscribed or narrowed over time due to efforts to implement one's self-concept and social valuations of occupations (Gottfredson, 1981). Gender and racial attributes can restrict perceived career options through processes of compromise and circumscription. This form of socialization begins early in life through gender- and racial-specific ideologies like parents treating sons and daughters differently based on gender stereotypes or schools enforcing discipline practices and

activities segregated by race. These socialization influences institutionalized patriarchal gender and racial ideologies, entrenching attitudes that constrain opportunities and self-concepts for African American girls (Hoominfar, 2003; Hoominfar, 2019). These factors influence African American girls to adapt to certain career choices they perceive are more suitable for them, thus limiting their career options and interests in male-dominated careers. The fAEC-KLM seeks to counteract these compromises by providing positive AEC experiences that broaden their perception of what is possible and desirable.

2.3.5 Witz's Social Closure Theory

This theory proposes that male-dominant groups preserve advantages by erecting barriers and restricting access to certain professions, credentials, and positions for women and racial/ethnic minorities (Walker, 2011; Witz, 2013). The impact of male-dominance in certain careers restricts the interests of African American girls for those careers. The inadequate study of female's career interest development and development of prominent theories on male career interest development has positioned masculine voices and values as the norm which overlooks the distinct moral voices and orientations that arise from female experiences. It is important to overhaul masculine bias in career interest theories and include the moral frames, social experiences, and voices of African American females (Gilligan, 1982). The fAEC-KLM aims to dismantle these barriers by equipping African American middle school girls with the knowledge skills, and confidence needed to challenge the status quo and access AEC careers.

2.4 Underrepresentation of African American Women in the AEC Professions

Workforce shortages have been a consistent problem in the Architecture, Engineering, and Construction (AEC) professions (Heydari et al. 2024; Statistics, 2021;Miller & Approach, 2001). Despite numerous job openings in AEC fields, women remain significantly

underrepresented worldwide, particularly in the United States. According to the US Bureau of Labor Statistics (2021), women make up only 20% of professionals in AEC fields, with women of color comprising just 9% of this group, including African American women. Similarly, only 7% of black women are in STEM fields and make up 1.6% of STEM professionals with bachelor's degrees (Dixon-Payne, 2022). Although women are equally capable, societal and employer biases often exclude them from certain roles and limit their potential to be seen as industry leaders (Carlone & Johnson, 2007). Given current workforce shortages in AEC, increasing African American women's representation could help address these gaps (Zweigg Group, 2022).

African American women bring different perspectives into career environments and industries, and these diverse perspectives improve the AEC industry (Nerej, 2021). The sole dependence on men to out designs and construction of significant infrastructures is limiting the potential to develop more gender-friendly built environments; hence the need for fresh, equally intelligent, and gender diverse minds (Hackett & Betz, 1981; McKissack, 2022). The way a woman thinks is entirely different from the thoughts of a man (Bussey & Bandura, 1999), so increasing gender diversity in the AEC workforce will improve innovation and diversity in current AEC products and services.

Eradicating workforce shortages by creating opportunities for African American women will not only benefit the AEC professions but will also create nationwide diversity and inclusivity in these professions (McKissack, 2022). The lack of African American women in STEM fields like AEC has been attributed to the lack of role-models and other structural barriers that black girls encounter. Therefore, there is considerable interest in the STEM career interest development in African American girls who were above 10.54 million in 2021(Black Women

Statistics. 2023). African American girls have unique needs that make them feel invisible and vulnerable (Dixon-Payne, 2022). Furthermore, the intersections of race, class, and gender presents difficulty and inequitable experiences that negatively impact their academic experience (Dixon-Payne, 2022).

2.5 Why African American Middle School Girls?

Studies have shown that the transition from elementary to middle school is usually difficult for girls. There is an increase in self-awareness and peer comparisons as girls become aware of how society views them (Norris, 2017b). Super (1953) describes this stage as the growth stage. Young African American girls at this stage are beginning to develop self-concepts, learning behaviors associated with independence, social interaction, self-direction, goal setting, and learning persistence. At this stage of their lives, most young girls are intimidated by what they see their peers involved in and tend to follow down similar paths (Patton et al., 2004b). Underrepresentation of African American girls in STEM begins early as they face difficulties cultivating STEM identities in primarily white and male STEM learning environments (Dixon-Payne, 2022). Middle school is an essential stage where they can be exposed to learning experiences that facilitate the merging of their female, African American and STEM identities.

YouScience (2024) revealed that black female students have 72% more aptitude than interest in Architecture and Construction. For most African American females, the encouragement to pursue any AEC profession from their families is almost non-existent. Although their brothers are encouraged to be engineers, architects, and construction managers, due to their gender, they are advised to pursue careers in health care and management (Furnham et al., 2002b; Inda et al., 2013b). While some girls develop self-efficacy in early stages of their lives which leads to career interests in male-dominated professions, others develop self-efficacy

much later due to barriers to include life experiences, environmental experiences, knowledge, mentorship, and family values (Schunk, 1991). Exposing African American middle school girls to AEC-infused OST programs will give them an early awareness and understanding that irrespective of environmental, gender, or race factors, they can venture into AEC careers and be successful in them. Educating, exposing, and encouraging young African American females to pursue professions in AEC is highly important.

Research has shown that at the middle school age, girls learn better by practicing what they see, and this shows in their fashion sense, speech, and walking styles (Serpe & Stryker, 2011). Hence, the importance of exposing them to hands-on learning projects (kinesthetic learning) related to AEC professions could present opportunities to increase their AEC career-related learning experiences, knowledge, self-efficacy, outcome expectations, and interests.

2.6 Types of Student Learning

Students can be categorized by the way they learn best. Students can be classified into four major types of learning using the acronym VARK: **V**isual learners, **A**uditory learners, **R**ead and write learners, and **K**inesthetic learners. Visual learners retain more information when lessons are presented in formats like charts, graphs, diagrams, and models. Auditory learners, on the other hand, absorb knowledge best through listening, while read-and-write learners benefit from reading and rewriting information in their own words. Kinesthetic learners retain knowledge through hands-on activities and real-life experiences (Moore, 2021). Kinesthetic learning is especially relevant to AEC fields, where tasks often involve hands-on projects like designing, assembling, and constructing (machine & life, 2017). While all learning styles have value in AEC professions, kinesthetic learning approaches are particularly beneficial for AEC learning.

2.7 Kinesthetic Learning

The great philosopher Aristotle once said that "for the things we have to learn before we can do them, we learn by doing them." This can be directly applied to the Science, Technology, Engineering, and Mathematics (STEM) domain, which includes AEC disciplines (Nancy, 2019b). AEC learning benefits from hands-on learning projects, assignments, and tests which provide insights into real-life problems and how they can be solved using necessary tools. It is safe to say that without kinesthetic learning, AEC learners will struggle in career roles.

Therefore, kinesthetic learning should be embedded into AEC experiences. Holland's theory on career identity also validates that individuals interested in and exposed to hands-on learning majorly fall into AEC professions and other hands-on professions. He categorized this career identity as "Realistic" - learners who fall into this category love to work with their hands, machines, tools, active, practical, and adventurous (Margaret, 2010).

2.7.1 Advantages of Kinesthetic Learning

Kinesthetic learning has a lot of advantages which makes it the best learning style for prospective AEC students. Some of these advantages are that kinesthetic learning helps strengthen working relationships with teamwork and projects, helps improve critical thinking and problem-solving abilities, increases information retention, encourages more engaged participation, and improves muscle memory (Moore, 2021). Kinesthetic learning also exposes students to real-life industrial or professional problems and provides resources on how to solve these problems (Paolo & Scott, 2007). Kinesthetic learning increases information retention when certain techniques are applied to a project in addition to movement and physical interaction; these help students retain information better (Califf, 2020). Kinesthetic learning also helps in

improving muscle memory which impacts decision making and organizational abilities especially with repetition of tasks (Elissa, 2014b).

Kinesthetic learning provides room for more engaged participation, with constant movement. While learning, energy is increased, which fuels engagement with written, verbal instructions, or passive information (Bangcola, 2016). Kinesthetic learning improves autonomy and self-confidence. Kinesthetic learning provides a self-paced environment for students, allowing them to discover new practices and work on them for as long as they need until they fully understand the concepts; this helps promote individual growth and confidence in self-abilities and progress (Culp et al., 2020). It exposes students to problem solving, which helps improve their analytical abilities through trial-and-error experimentation (Brecker & Azzam, 2022). Kinesthetic learning also helps learners strengthen working relationships; kinesthetic learning often requires teamwork, encouraging students to work together to accomplish the goals set before them and build trust in one another (Califf, 2020; Culp et al., 2020; Elissa, 2014b). Finally, kinesthetic learning helps students build refined risk assessment, this exposes the students to the concept of risk-taking and its importance in the promotion of growth and innovation within individuals (Bangcola, 2016; Begel et al., 2004).

2.7.2 Limitations of Kinesthetic Learning

Kinesthetic learning does have its disadvantages. Not all subjects can be effectively taught using this approach, and designing a lesson plan for kinesthetic learning can be more demanding. It requires crafting lessons that align with students' learning styles to make the experience interactive, engaging, and enjoyable (Moore, 2021). This is critical in activating and developing career interests especially in African American girls towards AEC careers.

2.8 Femalized Kinesthetic Learning

OST programs have been created to mentor young girls to develop AEC career interests in all girls AEC summer camps which adopt femalized kinesthetic learning strategies and environments (Ofori-Boadu, 2018; Ofori-Boadu et al., 2019; Ofori-Boadu et al., 2020; Ofori-Boadu & Sampson, 2022).

In order to reduce the underrepresentation of African American women in AEC careers, femalized kinesthetic learning OST programs create learning models that tailor to the female gender and provide safe learning spaces and where femalized stories and curricula are relatable to the female identities of participants. Burgess (2024) emphasized the importance of counter spaces to support STEM interests in African American girls. This learning approach for African American girls, integrates a female and African American culturally relevant approach into OST programs. Strategies such as female and African American role-models allow OST participants to remain in touch with their feminine and African American identities as they explore careers in which they are underrepresented.

2.9 Gap in Existing Career Development Literature

While women representation in some STEM careers has increased, they remain underrepresented in AEC careers. Furthermore, while girls have increased interests in careers such as Biology, they still have low AEC career interests (YouScience, 2024). This suggests that the interventions that worked for other STEM disciplines may not have worked in AEC domains. African American women remain underrepresented suggesting that gender and racial barriers continue to hinder AEC career interests in African American girls and prevent them from progressing into AEC undergraduate programs and professions. STEM education researchers suggest that gender and culturally relevant kinesthetic and project-based learning experiences

can be utilized in AEC-infused OST programs to increase AEC career interests in African American middle-school girls (Ofori-Boadu, 2018; Luster-Teasley et al. 2016; Natsir et al., 2016; Tyas & Safitri, 2017). Therefore, AEC-infused OST programs have been developed to engage middle-school girls in gender and culturally relevant kinesthetic learning experiences with the hope of increasing AEC career self-efficacy and interests. Serpe and Stryker (2011) noted that middle school girls learn better through practice, which is evident in their sense of fashion, speech, and walking styles.

Furthermore, curricula emphasizing spatial skills and creativity can make AEC subjects more appealing and better align with how girls prefer to learn (Marantika, 2022). Therefore, African American middle-school girls were found to benefit from femalized pedagogical approaches implemented in AEC-infused OST programs that emphasized collaboration, communication, and real-world applications over abstract concepts (Ewing & Yong, 1992; Hardy, 2017).

Luster-Teasley et al. (2016) incorporated female role models, role-playing, and storytelling in her OST program that engaged African American middle school girls in environmental science, water quality, and engineering kinesthetic learning experiences during their all-girls summer camp (Heydari et al. 2024). However, it only assessed program impacts on understanding, self-efficacy, and confidence. Also, Ofori-Boadu et al. (2019) reported an increase in minority middle-school girls' knowledge, self-efficacy, and persistence upon engaging them in biochar modified cement paste experiences and field trips at a historically black college. Furthermore, the integration of arts such as songs, sketches, and decorations contributed to improved learning, vicarious experiences, and emotional states. Findings indicated that self-efficacy gains were attributed mastery experiences (86%); emotional states (62%);

vicarious experiences (59%); and verbal persuasion (36%). Nevertheless, Ofori-Boadu et al. (2019) reported that lack of AEC career interests in a few girls during this AEC-infused OST program was attributed to discomfort with learning abilities, environments, processes, tools, and other competing career interests.

Ofori-Boadu (2018) incorporated dance as an art form into STEM projects in her all-girls AEC-infused STEM summer camp and observed an increase in self-efficacy, knowledge, and persistence (Ofori-Boadu, 2018). Although Ofori-Boadu (2018) adopted Lent's SCCT and found that implementing kinesthetic activities in a program for minority middle school girls resulted in improved outcomes, similar to other AEC-infused OST studies (Ofori-Boadu et al., 2019; Luster-Teasley et al., 2016), it lacked an intersectional lens that examines the compounding effects of gender along with racial identities on AEC career interests. The intersectionality lens permits examination of how interlocking systems of race and gender influence AEC career interests (Kimberly, 1989).

Another relevant study by Safapour and Kermanshachi (2020) addressed the issue of increasing representation of Hispanic women in construction fields, where they are severely underrepresented. This study also utilized SCCT, recruited only Hispanic girls, and implemented workshops and role modeling by inviting industry and academia construction professionals to share their success stories and challenges, resulting in the increase of career perception to pursue construction engineering careers. However, it did not deeply explore kinesthetic activities nor intersectional issues such as acculturation levels and ethnicities beyond "Hispanic," nor did it provide assurances that its findings could be generalized to address career interests in African American middle school girls. Insights into understanding of African American middle-school

girls AEC-career interest development is crucial because of their uniqueness and the continued underrepresentation of African American women in AEC careers.

Considering that African American middle-school girls' identities and lived experiences are significantly different from non-black girls, black boys, black women and other adult populations, AEC-infused OST interventions will benefit from empirical work that increase nuanced understanding of how African American middle-school girls develop AEC-career interests through AEC-infused OST programs (Betz, 2023; Hackett & Byars, 1996). Existing career interest development theories and findings from empirical studies mostly draw from populations with limited representation of African American girls and cannot be fully generalized and applied in OST interventions to increase interests in male-dominated careers. Male-dominated careers such as AEC careers present processes and cultures that are usually unwelcoming to African American girls and therefore understanding how they interact within such domains based on their salient identities and learning interactions will fill gaps that exist in current career development literature.

CHAPTER 3

Methodology

3.1 Introduction

This research adopts a mixed-methods approach involving the analysis of data obtained from surveys, interviews, tests, and observation to investigate how salient identities of African American middle school girls interact with learning experiences within a developed femalized AEC kinesthetic learning model to impact AEC career interests. Participants completed pre-intervention interviews, surveys, and tests before interaction with the fAEC-KLM and post-intervention interviews, surveys, and tests after fAEC-KLM interactions. The impact of the fAEC-KLM model on participants' career-related learning experiences and AEC knowledge, skills, opportunities, and interests (KSOIs) were evaluated using both quantitative and qualitative analysis. Pre- and post-intervention responses were analyzed using statistical package for social sciences (SPSS) and Microsoft Excel spreadsheet software for statistical analysis, while NVIVO qualitative data analysis software was employed for qualitative data analysis. In this chapter, first, an introduction to the mixed methods research approach is given with detailed advantages of using this research approach for this study. Also, the data collection processes as well as the data analysis processes and tools are discussed.

3.2 Mixed Methods Research Approach (MMRA)

The mixed methods research approach combines elements of both qualitative and quantitative research methods to answer the research questions of this study (George, 2022). MMRA gives researchers the flexibility to employ diverse methods to help combine inductive and deductive thinking to reduce the limitations of using either quantitative or qualitative research exclusively. It also to provides a complementary approach to enhance the strength of

both qualitative and quantitative data types to produce a more comprehensive understanding of the issues needed to be solved (Havard, 2022). Effective MMRA requires more than simply using both qualitative and quantitative methods in parallel. The key lies in identifying meaningful integration points where these approaches converge and complement each other, ultimately producing a more comprehensive understanding of the research problem (Havard, 2022; Schoonenboom & Johnson, 2017).

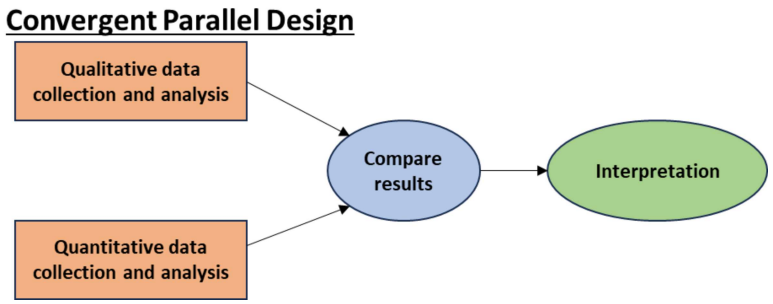


Figure 5. Mixed Methods Research Approach Convergent Parallel Design (MMRA-CPD)

This study employs a Convergent Parallel Design (CPD), in which quantitative and qualitative data are collected and analyzed simultaneously. The findings from both approaches are then integrated to develop a comprehensive interpretation of the results. *Figure 5* shows the process involved in an MMRA-CPD. This mixed-methods approach enables the identification of convergent and divergent patterns between quantitative and qualitative findings. The data collection process consists of two parallel streams. The qualitative component involves one-hour semi-structured Zoom interviews, which are coded using NVIVO qualitative analysis software to analyze participants' salient identities, initial AEC-related learning experiences, and KSOIs. The quantitative component utilizes 5-point Likert scales, ranking questions, and tests analyzed through SPSS and Microsoft Excel to provide statistical measurements of these same metrics. The findings from both methods are then synthesized to address the study's research questions, highlighting areas where the data streams complement or contrast with each other.

3.3 The Model: Femalized AEC Kinesthetic Learning Model (fAEC-KLM)

Kinesthetic learning has been utilized in AEC-infused OST programs to increase AEC career-relevant self-efficacy and interests in African American middle school girls (Luster-Teasley, 2016; Ofori-Boadu, 2018). This chapter gives a detailed explanation of the creation and implementation of the proposed model for understanding AEC carer interest development in African American middle school girls through AEC-infused OST programs.

The femalized Architecture, Engineering, and Construction Kinesthetic Learning Model (fAEC-KLM) is an out-of-school-time (OST) learning module that aims to understand and improve AEC-related learning experiences, knowledge, self-efficacy, outcome expectations, and interests (KSOIs) in African American middle school girls.

The idea behind the fAEC-KLM is to use kinesthetic (hands-on) learning to increase AEC-related learning experiences, knowledge, self-efficacy, outcome expectations, and interests (KSOIs) in African American middle school girls. The projects were obtained from the teach engineering website (*Ignite STEM Learning in K-12 - TeachEngineering*, 2022). The website offers a comprehensive collection of grade-appropriate projects designed to expose K-12 students to potential career pathways through hands-on exercises. Its selection was based on both the diversity of available projects and the detailed, step-by-step instruction provided for each activity. Building on these resources, the fAEC-KLM was implemented in the 2023 STEAM Activated! summer camp with the following objectives:

- Provide African American (AA) middle school girls with the opportunity to learn about AEC careers alongside other AA girls in an all-female and African American counterspace and learning environment (Burgess, 2024).

- Engage AA middle school girls in tailored fAEC-KLM to evaluate model impacts on their AEC career interests and other outcomes.
- Enable interactions between AA middle school girls, successful AA AEC undergraduate women and professionals to increase access to role models.
- Expose AA middle school girls to AEC learning environments at a Historically Black College and University (HBCU).

3.3.1 Components of the fAEC-KLM

The fAEC-KLM consists of 20 components. *Table 1* lists the components and the associated Bandura's self-efficacy sources that informed component development.

Table 1. *fAEC-KLM Components and Bandura's Self-efficacy Theory*

fAEC-KLM Components	Bandura's Self-efficacy Sources
Lecture on AEC and fAEC-KLM	Verbal Persuasions
Lecture on self-efficacy and identity	Verbal Persuasions
Lecture on bridge design and construction	Verbal Persuasions
Interaction with peers (other girls).	Vicarious Experiences
Interaction teammates (assigned partner for project)	Vicarious Experiences
Interaction with undergraduate panelists	Vicarious Experiences
Bridge design	Mastery Experiences
Bridge construction	Mastery Experiences
Incorporation of feminine products to project design and construction	Mastery Experiences
Interaction with instructors	Vicarious Experiences
Mathematical calculations for bridges	Mastery Experiences
Project presentation	Mastery Experiences
Response to questions asked	Physiological Feedback
Awards ceremony	Physiological Feedback
Documentary of female African American AEC professionals.	Vicarious Experiences
Success stories of female African American AEC undergraduate students on journeys from childhood to being an AEC student.	Vicarious Experiences
Classroom setting	Vicarious Experiences and Physiological Feedback
Teamwork	Vicarious Experiences
Lunch	Vicarious Experiences
Lecture on salary benefits of AEC professionals	Verbal Persuasions

3.3.2 fAEC-KLM Daily Schedule

The fAEC-KLM is a five-day (Monday – Friday) program that comprises of AEC related lectures, interactive sessions, documentary, success stories and more. Participants spent 7 hours each day carrying out these activities (*Appendix B.1*). The hourly schedule of fAEC-KLM is shown in *Table 2.*

Table 2. *Hourly Schedule of fAEC-KLM Activities*

Days	Activities
Monday	• 9am – 10am: Interactive Session among participants • 10am – 11am: Orientation, code of conduct, completion of pre-survey and pre-test • 11am – 12pm: Lecture on Self-efficacy and Identity • 12pm – 1pm: Lunch break • 1pm – 2pm: Lecture on AEC and fAEC-KLM • 2pm – 3pm: Lecture on Bridge Construction • 3pm – 4pm: Interactive session among participants
Tuesday	• 9am – 10am: Documentary on African American female AEC professionals • 10am – 12pm: Development of individual designs • 12pm – 1pm: Lunch break • 1pm – 3pm: Team pairing and final project planning. • 3pm – 4pm: Interactive session with teammates
Wednesday	• 9am – 10am: Sorting out materials for bridge project. • 10am – 12pm: Teams working on projects. • 12pm – 1pm: Lunch break • 1pm – 3pm: Panel session with AEC female undergraduates • 3pm – 4pm: Interaction with AEC panelists
Thursday	• 9am – 12pm: Final touches on project • 12pm – 1pm: Lunch break • 1pm – 3pm: Presentation plan • 3pm – 4pm: Interactive session with participants
Friday	• 10am – 12pm: Project presentations • 12pm – 1pm: Lunch break • 1pm – 2pm: Completion of post-survey and post-test

Day 1: On day one, participants spent the first hour getting to know each other, after which the code of conduct for the program was read to African American middle school girls. QR codes were displayed to complete both the presurvey and pretest. The PI then introduced herself and gave the opportunity for each participant to do the same. The lectures on self-efficacy, identity, AEC, the fAEC-KLM model, and bridge construction were then taught.

Day 2: Day two also consisted of seven (7) hours of activities from 9 am to 4pm. Considering the role of female role models in inspiring AEC career interests (Heydari et al., 2024; Luster-Teasley et al., 2017; Ofori-Boadu, 2018), the first hour was used to present a lecture series on some successful female African American professionals, their roles in representing females in the AEC professions, and their notable achievements. This series was divided into professionals in Architecture, Engineering, and Construction with history of at least three professionals in each category. Participants were also introduced to two female AEC professionals who educated the girls on their professional journeys, achievements, and best practices for achieving success in AEC professions. They also elaborated on bridge constructions which would be the main kinesthetic learning project for this camp. The participants then sketched their bridge designs based on the types of bridges presented to them in the bridge lecture. They were to sketch and design the bridge that they would love to build and incorporate anything linking their designs to the successful female AEC professionals presented to them in the lecture series. They also had to include a feminine product in their bridge design. After the lunch break, research participants (RPs) were paired into groups of two and each group selected one out of their bridge designs to construct. They used the final hour to plan how to best construct their designed bridges. The idea was to construct a bridge that could hold at least a one-pound weight, had an attribute of a successful African American AEC female professional, and

incorporate a feminine product (it could be female cosmetics, health products, apparels, anything feminine), and finally show the mathematical calculations for their bridge designs.

Day 3: The first hour was used to select materials needed for the bridge construction project from available materials provided to RPs. Materials included 2mm thick foams, toothpicks, rulers, skewers, 12 x 4-inch cork tiles, strings, tapes, markers, embroidery needles, sanitary pads, tampons, lipsticks, eyeliners, color pencils, cardboard, pencils, scale, and scissors. The next two hours were dedicated to working on the bridge project, after which they had a one-hour lunch break. After the lunch break, a panel session with current female African American female AEC undergraduate students was held. These students narrated their success stories from childhood to becoming an AEC undergraduate student. The RPs were given the opportunity to ask these students questions about being AEC undergraduates during the one-hour interactive session.

Day 4: RPs continued working on their projects. They had some problems getting the glue to dry quickly. They were also provided with glue guns, but those also kept getting stuck. However, RPs persevered and ensured that they did everything possible to get their bridge projects constructed. They also started preparing for their bridge project presentation. For presentations, they needed to discuss the reasons for their designs, what the design entails, the mathematical calculations for their design, the female AEC professional that their design represents, and the weight that their bridge could support.

Day 5: Due to some complications with glue from the previous day, RPs spent a couple more hours on this day putting finishing touches to their projects. Presentations were scheduled for 1pm and parents and guardians showed up to watch their daughters present their completed bridge projects. A panel consisting of the camp instructor, two female African American AEC professionals, and one parent were responsible for awarding grades to the presentations using a

provided rubric as guide. The team with the best and strongest design built a bridge that held over 80 pounds of weight. The weakest bridges supported 30 pounds which was exciting to see – recall that the requirement was for the bridge to hold at least one–pound weight. The bridges built by the RPs were very sturdy and strong. To conclude the events for the last day, QR codes were presented to RPs to complete both post survey and test. They also schedule a time for the post interviews before leaving the camp.

All activities associated with this model were designed to answer the research questions stated in Chapter 1 and strictly following the research methodology detailed in Chapter 1. With these five days of activities, the KSOIs of the RPs were impacted as explained in chapter 4.

3.4 Data Collection

3.4.1 Sampling and Recruitment

Processes such as IRB approval, consent forms, flyers, and application forms were completed before any data collection commenced (*Appendices A.0-A.4*). This research adopts a mixed-methods approach using interviews, surveys, and tests collected before and after participants' interactions with the fAEC-KLM. Furthermore, data was obtained through real-time observations through video recordings. To ensure that this study satisfies all human subject research, approval was obtained from North Carolina A & T State University's Institutional Review Board (IRB) prior to data collection. Parental permission forms and participant consent forms were also completed by RPs and their parents. The fAEC-KLM was implemented through STEAM Activated! summer camp hosted by the Emerging Built Environment Women (EBEW) center at North Carolina Agricultural and Technical State University.

Recruitment flyers (*Appendix A.1*) containing a description of the study and a link to the application form was distributed to administrators and teachers at middle schools in Guilford

County, NC. Application form (*Appendix A.2*) contained questions requesting demographic information and reasons for wanting to participate in this research study (David, 2017). A total of sixteen (16) African American middle school girls were recruited, however only fourteen (14) completed interviews, surveys, and tests before and after interacting with the fAEC-KLM. The same set of questions were asked for pre and post data collection.

3.4.2 Data Collection Methods

3.4.2.1 Qualitative Methods

Interviews: Semi-structured interviews (*Appendices A.5, C.3*) utilizing the critical incident technique (Flanagan, 1954; Viergever, 2019) consisted of 13 open-ended questions. They were conducted to obtain knowledge and understand RPs identities, learning experiences, and other salient drivers of AEC career interests. Utilizing the critical incident technique gave the interviewer the opportunity to understand the changes in AEC related learning experiences, knowledge, self-efficacy, outcome expectations, and interests of the RPs while also gaining knowledge on how best to improve their performances and experiences after interacting with the fAEC-KLM. Questions asked included an overview on RPs' personality, future career aspirations, and other career-relevant development questions (Margaret, 2010). The pre-interview served as a baseline to compare future responses from post-survey and test to understand the trends and patterns of salient identities of the RPs prior to exposure to the fAEC-KLM while the post-interview permitted comparison to assess career-relevant changes. Follow-up questions were asked during the interviews to ensure that RP responses were based on their perspectives and not on the views of their parents, guardians, or any other important figures in their lives. Interview questions also verified if RPs had ever been exposed to any kinesthetic learning model prior to participating in fAEC-KLM. The interviewer ensured that the follow-up

questions were clarifying but not leading towards a desired response. All interviews were conducted utilizing the zoom video conferencing platform and lasted about one hour.

3.4.2.2 Quantitative

Surveys: Aside from general demographic questions related to race, age, current grade questions, the survey (Creswell & Creswell, 2009; Kornheiser, 2022) also obtained pertinent data on the learning experiences, knowledge, self-efficacy, outcome expectations, and interests of the RPs (*Appendices A.6, C.1*). The survey comprised of two sections. In the first section, RPs were provided with the 20 components of the fAEC-KLM and asked to rank these components from one (1) as most effective to twenty (20) as least effective in impacting their AEC career interests. The second section comprised of 5-point Likert scale questions, where RPs were to select a (Strongly Agree, Somewhat Agree, Neither Agree or Disagree, Somewhat Disagree, and Strongly Disagree) that reflected their level of agreement with statements related to pre- and post-surveys were utilized to estimate model impacts on KSOIs outcomes.

Test: Test questions (David, 2017) were utilized to assess general knowledge of AEC professions and salient identities within AEC, identities of successful female African American AEC professionals, bridges, sustainability materials for bridges, mathematical problems involving bridges, and the benefits attached to being an AEC professional (*Appendices A.7, C.2*).

Observation: Activities within the fAEC-KLM for the five days of summer camp were observed utilizing video recording (Chouhurg, 2015; Groenendijk et al., 2013). Three separate 360 cameras were placed at different locations in the room used for the summer camp to capture activities of RPs from different positions. In total, 180 hours (i.e., 6hrs per day X 5 days X 3 cameras) of activities were captured and stored on external hard drives for analysis (*Appendix B.2*).

3.5 Data Analysis

3.5.1 Qualitative Analysis – Interview

After data collection, all identifying information of RPs was removed and RPs were assigned unique identifiers (AAMG#...). NVIVO qualitative analysis software was used to conduct constant comparative analysis to develop themes and definitions based on responses given by RPs with respect to their KSOIs.

An interpretivist epistemology was employed to explore the learning experiences of African American middle school girls and how these experiences influence their AEC career interests and other outcomes (Potrac et al., 2014; Scauso, 2020). The recorded interviews were transcribed and analyzed using inductive thematic analysis (Braun & Clarke, 2006, 2012, 2022; Clarke & Braun, 2013, 2017). This approach systematically identifies, organizes, and provides insights into themes across a qualitative dataset, distinguishing between "semantic" (explicit) and "latent" (underlying) themes. Following the six steps of thematic analysis—familiarizing with the data, generating initial codes, searching for themes, reviewing potential themes, defining, and naming themes, and producing the report—coders collaborated to ensure unbiased data reporting.

Transcripts were thoroughly read and re-read to increase familiarity with the data and identify emerging themes. NVIVO qualitative analysis software facilitated constant comparative analysis, using gerunds during the initial open coding phase. Open codes (both latent and semantic) captured specific words, rankings, phrases, and terms that RPs used to describe their learning experiences and AEC career-related outcomes. The NVIVO software tracked the number of references (N) for each code, with frequency used to determine commonalities across the RPs' experiences and rationales. Coders agreed on sub-themes, themes, and pattern codes to ensure all descriptions and experiences were adequately captured.

3.5.1.1 Knowledge

The interview included three open-ended questions related to RPs' knowledge of AEC careers and its impact on their AEC career related interests and decisions. Special emphasis was placed on knowledge of female and African American participation in AEC careers.

1. "Tell me what you know about female and African American participation in AEC careers."

2. "On a ranking scale of 1 (lowest) and 5 (highest), to what extent do you think you have the knowledge needed to make a decision about pursuing an Architecture, Engineering, and Construction (AEC) career? Explain how lived and learning experiences have contributed to your rank."

3. "How did the most effective component of the fAEC-KLM contribute to increasing knowledge needed to make AEC career decisions?"

Fourteen (14) open codes emerged at the end of this phase ensuring that only frequent codes fully agreed upon by the coders were included in the findings.

The second phase of coding progressed into six (6) focused coding where open codes with similar characteristics were grouped together to best express experiences and reasonings described by RPs.

The third phase of coding involved more grouping of the focused codes into themes and sub-themes that best reflect the patterns in AEC career knowledge of the RPs. In this phase, two sub-themes emerged: (1) Attributing Pre-Intervention AEC Knowledge to Previous AEC-Infused Formal and Informal Learning Experiences, (2) Attributing Post-Intervention AEC Knowledge Gain to fAEC-KLM. These sub-themes were captured under one central theme, *"fAEC-KLM*

Increases AEC Knowledge in African American Middle School Girls." The central theme provides detailed information into how AEC knowledge impacted AEC career-related decisions. The central and sub-themes are further explained with percentages of references per code and RP quotes were utilized to explain findings (*Appendix D.1*).

3.5.1.2 Self-efficacy

First phase: Eighteen (18) open codes emerged at the end of this phase.

Second phase of coding: Five (5) focused codes.

Third phase: Two sub-themes emerged: (1) Attributing Pre-Intervention AEC Self-efficacy to Informal, Formal, or Self-expressed Learning Experiences, (2) Attributing Post-Intervention AEC Self-efficacy to fAEC-KLM. These sub-themes were captured under one central theme, *"fAEC-KLM Impacts AEC Self-efficacy of African American Middle School Girls."* The central and sub-themes are further explained with percentages of references per code and quotes made by RPs to support codes (*Appendix D.2*).

3.6.1.3 Outcome Expectations

First phase: Eighteen (18) open codes emerged at the end of this phase.

Second phase: Five (5) focused codes.

Third phase: Two (2) sub-themes emerged: (1) Highlighting Pre-Intervention AEC Outcome Expectations, (2) Highlighting Positive and Negative AEC Outcome Expectations. These sub-themes were captured under one central theme, *"fAEC-KLM Impacts AEC Outcome Expectations of African American Middle School Girls."* The central and sub-themes are further explained with percentages of references per code and quotes made by RPs to support codes (*Appendix D.3*).

3.5.1.4 Interest

At the end of the first phase, there were sixteen (16) open codes. As coding progressed, codes were merged or modified to better capture emerging interpretations of RPs' experiences.

The second level of coding progressed to focused coding analysis, where initial open codes with similar characteristics were grouped. For example, gaining knowledge on AEC math calculations, and gaining knowledge on bridge design/construction shared a unifying theme of Gaining knowledge on AEC related experiences, resulting in the emerging focused code labeled *Attributing to knowledge gain on AEC technical experiences.* At the end of this phase, eight (8) focused codes were recorded.

For the third level of coding, focused codes were aggregated into sub-themes that captured unifying attributes of interest impactors. Three sub-themes were generated which are, attributing to gain in AEC knowledge, attributing to gain in sense of belonging, attributing to gain in self-efficacy. These three sub-themes together captured the different components of the fAEC-KLM that increased AEC interest in the research RPs. An emergent central theme, *fAEC-KLM Components Increase AEC Career Interests*, umbrellas all rationales captured by the sub-themes. The central theme encapsules the explanations given by RPs that are relevant to the research question.

The central theme and three sub-themes are explained in subsequent paragraphs, with the number of references per code and participant quotes supporting the codes.

Pattern coding was also conducted by coders to show the variations in AEC career interests exhibited by RPs. This level of coding was used to categorize the AEC career interests experienced by RPs and attributes unique to each category. Key determinant of interest

categories RPs fall under is their self-ranked AEC interest on a scale of 1 as the lowest to 5 as the highest. Rankings of High (4 or 5), Mid (3), Low (1 or 2), Yes, or No (to show presence or absence of career-related attributes) were also used to capture other attributes that contribute to interest categorization (*Appendix D.4*). These categories are elaborated in subsequent paragraphs with percentages of RPs. Codes at each level of coding are summarized in *Table 3*.

Table 3. *Summary of AEC Metrics and Emerging Codes for Each Level of Coding*

Variables	**First Level Codes (Open Codes)**	**Second Level Codes (Focused Codes)**	**Third Level Codes (Sub-themes)**
Knowledge	14	6	2
Self-efficacy	18	5	2
Outcome Expectations	18	5	2
Interest	16	8	3

3.5.2 Quantitative Analysis – Survey, Test, and Observation

3.5.2.1 Survey

Mean ranks were calculated for Qualtrics based survey responses. Using the calculated mean ranks, the Wilcoxon Signed-Rank test (Rosner et al., 2006; Taheri & Hesamian, 2013) was carried out on the fAEC-KLM component ranking responses and t-test (paired two sample for means) was carried out on the Likert Scale responses.

3.5.2.2 Test

Qualtrics based test questions comprised of questions on general knowledge of AEC professions, types of bridges, bridge construction, force and mathematical calculations of bridges, sustainable materials for bridge construction. Test questions were grouped into

categories such as AEC roles and responsibilities, AEC salary benefits, AEC intersectionality, and Bridge Construction. Correct answers were represented by 1 and wrong answers by 0.

SPSS and Microsoft Excel were used to carry t-test (paired two sample for means) (De Winter, 2019; Manfei et al., 2017) on the mean value of the responses to evaluate differences in test scores from pre- and post-tests.

3.5.2.3 Observation

Insta 360 software (Tang & Zhang, 2019) was employed to track individual activities throughout the fAEC-KLM. These videos were translated using virtual timing device (VTD) to systematically log patient behaviors, skill applications, and engagement status. Given the extensive amount of video data available, only activities associated with the three most effective components of the fAEC-KLM were selected for detailed analysis to ensure meaningful insights.

Three distinct VTD templates were developed, each corresponding to one of the three most effective components of the fAEC-KLM. Each templated contained three structured segments to standardize data capture:

Segment 1: Career-Relevant Self-Attributes

This segment captured career-relevant self-attributes mentioned by RPs in interviews and surveys e.g., Creative attributes, social, attributes, and analytical attributes.

Segment 2: Engagement Status

This captures when the RP is actively engaged or unengaged in a component-related activity.

Segment 3: Activity-Specific Behaviors within fAEC-KLM Components.

Some examples of logged activities and behaviors are:

AEC Lectures:

Notetaking	Actively taking notes during lectures

Asking_Questions	Seeking clarity from instructor or peers during lectures
Answering_Questions	Providing answers to questions asked by instructor or peers
Agreeing_to_Statements	Agreeing to statements made by instructor or peers
Peer_Interaction	Maintaining or having lecture-related conversations with peers
Distracted	Doing something else other than all other activities listed here.

Bridge Construction Project:

Kinesthetic	Actively working on bridge construction
Team_Interaction	Actively communicating with teammate while working on bridge project
Leadership	Taking lead on bridge project while teammate watches
Design	Actively sketching or describing what bridge should look like to teammate.
Problem-solving	Providing a solution to a problem encountered during project
Independent	Working on project alone without teammate nearby
Math	Actively calculating math related to bridge project
Inquisitive	Asking teammate or instructor for clarification or insight into project
Helping_Others	Assisting other teams with bridge project
Providing_Ideas	Actively providing suggestion on how best to carryout project
Critical_Thinking	Actively brainstorming with teammate on how to make project better
Decision_Making	Agreeing or deciding on suggestions made with teammate

Peer Interactions:

Conversation_with_Peers	Having conversations with other girls in the room
Conversation_with_Teammate	Having conversations exclusively with teammate

Listening	Actively listening to conversations with teammate or peers
By_self	Sitting alone away from others – engaged in another activity
Uninteractive	Sitting with a group but not participating in conversations

During the video analysis, RPs recorded footage and relevant VTD template were placed side by side. Corresponding activities were clicked in real-time, logging activity type and duration (in seconds). Videos were analyzed in one-hour periods to maintain accuracy and prevent fatigue, ensuring thorough analysis. Once the vide observations were completed, the activity durations and engagement levels were exported to SPSS for further descriptive analysis and engagement percentage calculations (Cooksey & Cooksey, 2020; George & Mallery, 2018). Examples of the templates are given in *Figure 6*.

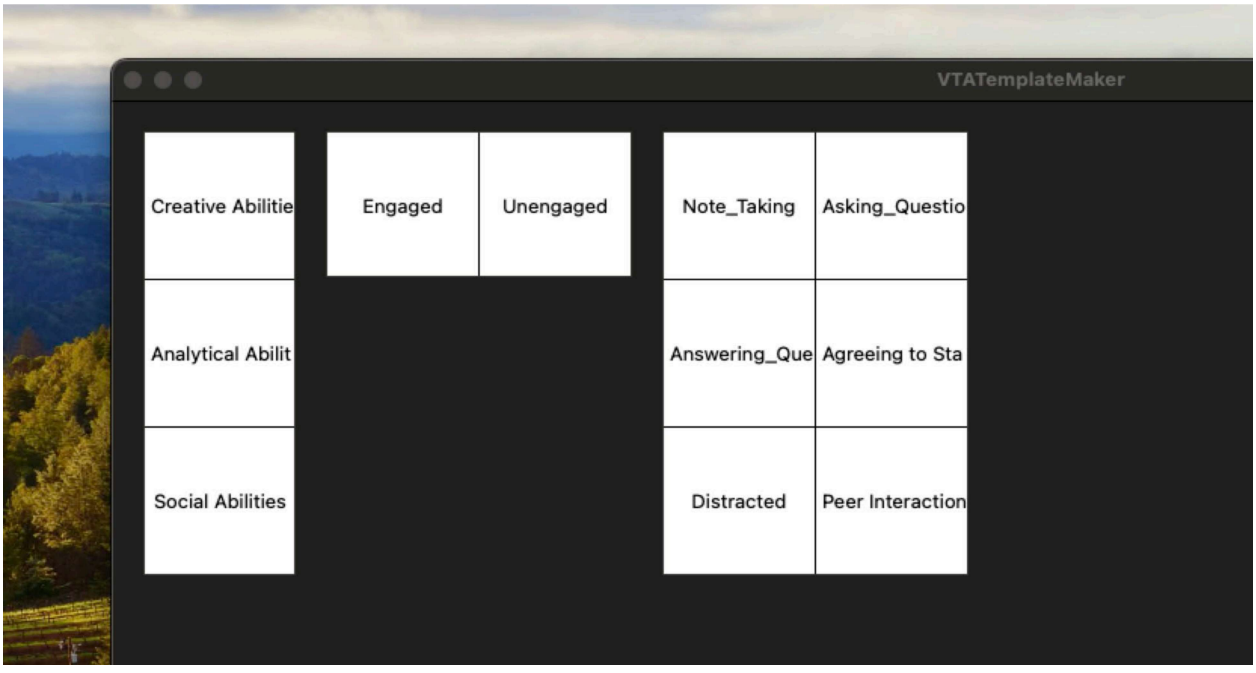


Figure 6. VTD Template for AEC Lectures.

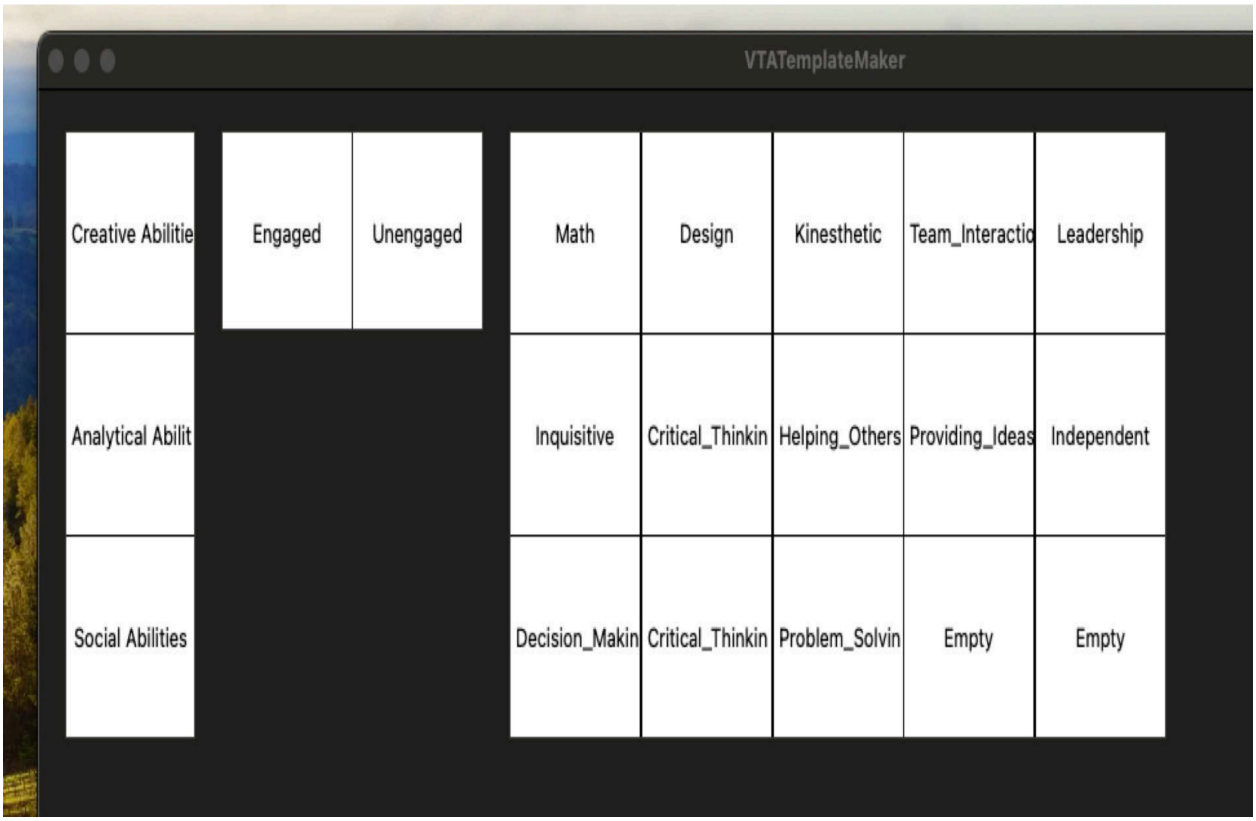


Figure 7. VTD Template for Bridge Construction Project

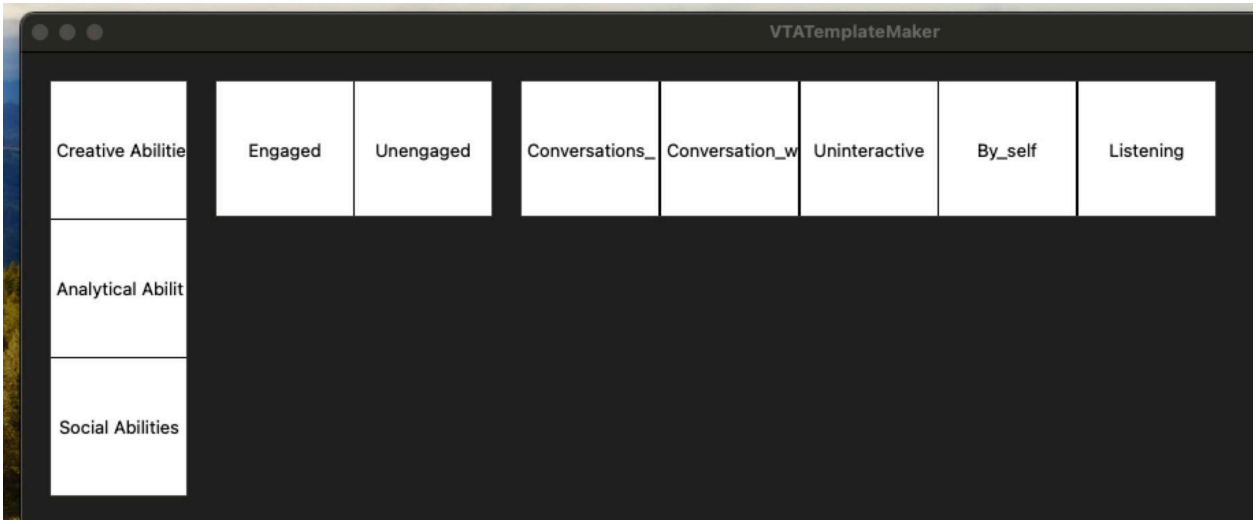


Figure 8. VTD Template for Peer Interactions

Due to the preset grid sizes of the VTD templates, all activities could not be displayed correctly. However, activities are described in *section 3.5.2.3* above.

3.5.3 Reliability and Validity Test for Analysis

3.5.3.1 Interview

1. The research team transcribed interviews, developed memos, and conducted bi-weekly meetings to discuss findings and compare memos on characteristics and codes captured from transcripts (Saldana, 2011) .
2. The coders conducted constant comparative analysis to ensure all characteristics, words, and phrases were captured accurately (Von Glasersfeld, 1982). The coders also revised focused codes and agreed on sub-themes, themes, and pattern coding to ensure all descriptions and experiences were adequately captured without bias.
3. Triangulation was also carried out – comparing interview findings with other data sources e.g., observations, surveys (Theron, 2015).

3.5.3.2 Survey

Pilot surveys (Hertzog, 2008; O'Neill, B., 2022) were administered to 10 African American middle school girls to determine if the survey was efficient and easily understood by middle school girls. Results from pilot study resulted in changes to be made such as increasing survey completion time to 15 minutes instead of the previously allocated 10 minutes since the average completion time for the pilot survey was ~13.9 minutes. Also, explanations to some unavoidable complicated words like kinesthetic (hands-on) were added, and the usage of simplified words ensured improved understanding. The “I do not know” option was also included to give RPs an option to express their level of knowledge especially if it is not one of the options listed in the multiple-choice questions.

3.5.3.3 Test

Cronbach's alpha was used to measure the internal consistency of the test results. Cronbach's alpha is a measure of internal consistency, ranging from 0 to 1 (Taber, 2018; Tavakol & Dennick, 2011). Higher values indicate greater internal consistency. The test scores of the thirty-two (32) questions for pre- and post-tests were inputted into SPSS and a reliability test carried out. The Cronbach's alpha was 0.682, which according to the guide provided in (Kline, 2013), is a questionable value. However, this low value can be due some reasons:

i) Some questions had multiple answers and RPs scored a zero if all answers were not selected.

ii) There was no pilot testing to evaluate question clarity and level of understanding of test questions. Therefore, there is a possibility of some difficulty in understanding test questions.

iii) This study has a very small sample size of 14 RPs which can cause little variability in responses leading to the low alpha value.

CHAPTER 4

Results and Discussion

4.1 Introduction

The purpose of this study is to understand how salient identities of African American middle school girls interact with learning experiences within a developed femalized AEC kinesthetic learning model (fAEC-KLM) to impact AEC career interests. To address this purpose, three research questions were utilized:

1. What are the most effective components of the fAEC-KLM in increasing AEC career interest?
2. How do salient identities of African American middle school girls interact with learning experiences in the fAEC-KLM?
3. To what extent does the fAEC-KLM impact AEC career knowledge, self-efficacy, outcome expectations, and interests in African American middle school girls?

A summary of the methods utilized for each research question (RQ) is given in *Table 4*:

Table 4. *Summary of Research Questions, Methods of Data Collection, Analysis Tools Used, and Analysis Carried Out*

Research Questions	**Methods**	**Analysis Tools**	**Analysis**
RQ 1	Interviews and Surveys	NVIVO SPSS/Excel	Thematic Analysis, Wilcoxon Signed-Rank Test
RQ 2	Interviews and Surveys	NVIVO SPSS/Excel	Thematic Analysis, T-tests
RQ3	Interviews, Surveys, Tests, Observation	NVIVO SPSS/Excel	Thematic Analysis, T-tests, Descriptive Statistics

4.2 Recruitment and Enrollment of Research Participants

Eighteen (18) African American middle school girls completed the application forms and seventeen (17) were interviewed and enrolled in the STEAM Activated! summer camp to interact with the fAEC-KLM. Sixteen (16) girls started the summer camp but only fifteen (15) completed. One dropped out of the program due to personal reasons. Two RPs reported late to the program on the first day after pre-survey and pre-test were already completed and so did not participate in initial data collection process. One research participant (RP) failed to schedule a post-interview. Responses tallied for this study are as follows: Seventeen (17) pre-interviews, thirteen (13) pre-surveys and tests, fifteen (15) post-surveys and tests, fourteen (14) post-interviews. In summary, thirteen (13) surveys, fourteen (14) interviews were analyzed, and fifteen (15) were observed.

4.3 Demographics of Research Participants

As shown in *Figure 9*, the 14 RPs who completed all phases of data collection consist of 6th graders (17%), 7th graders (58%), and 8th graders (25%) ranging from ages 10 to 13 years. Among these RPs, three reported having household members working as STEM professionals, while two have family members in AEC-related professions.

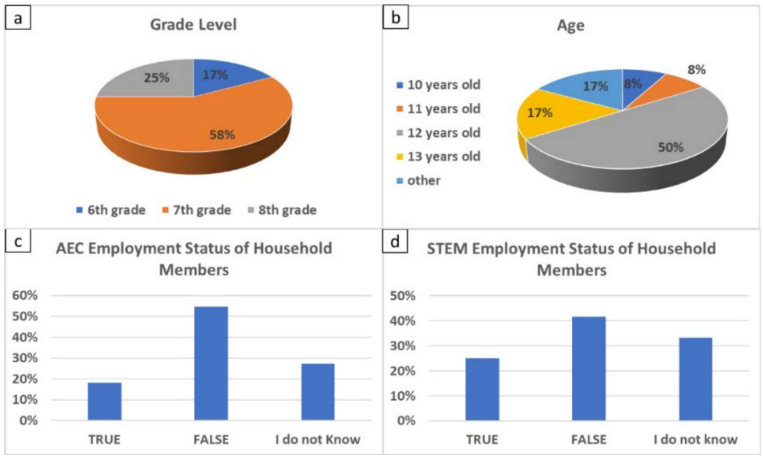


Figure 9. a) Grade Level; b) Age; c) AEC Employment Status of Household; d) STEM Employment Status of Household.

4.4 Research Question 1: ***What are the most effective components of the fAEC-KLM in increasing AEC career interests?***

Of the 20 components listed in *Table 1*, the most effective components in increasing AEC career interests were ranked by the RPs in the interviews and surveys are analyzed using thematic analysis of interview data and ranking method/t-test for surveys.

4.4.1 Thematic Analysis of Interview Data:

RPs were asked the question: *"How did the most effective component of the fAEC-KLM increase your AEC career interests?"* Thematic analysis revealed that the three most effective components of the fAEC-KLM are AEC/fAEC-KLM lectures, bridge construction project, and peer interactions. Descriptions and statements of how these effective components impacted the AEC career interests of the RPs are captured in the central theme and sub-themes. The central theme, *fAEC-KLM Components Increase AEC Career Interests*, explains how specific fAEC-KLM components contributed to AEC career interests**.** It also embodies the rationales captured by the sub-themes. The sub-themes are summarized in *Figure 10* and subsequent explanations.

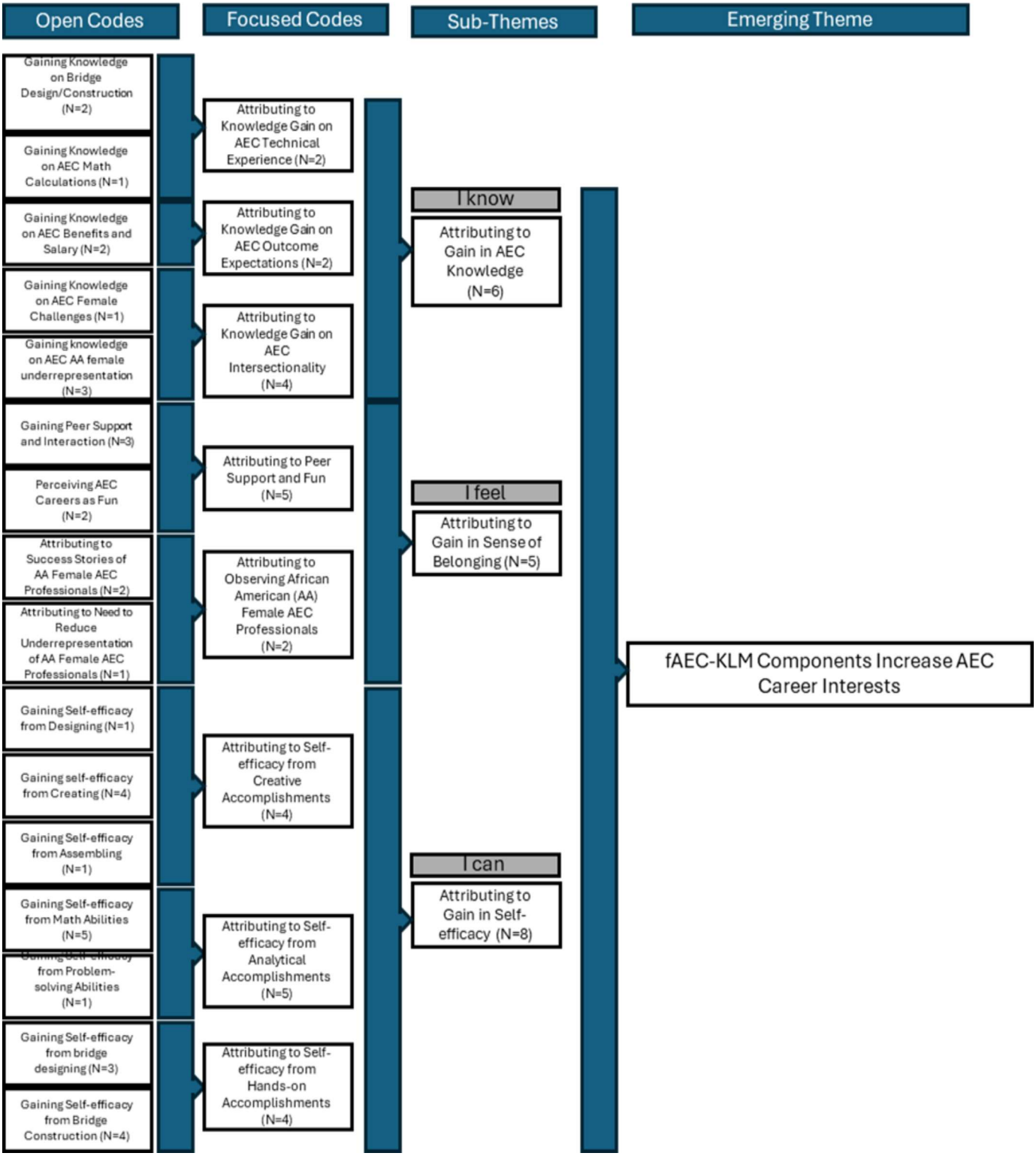


Figure 10. Theoretical Coding Structure of fAEC-KLM's Impact on AEC Career Interest

with related quotes give insights into how the fAEC-KLM model increased the AEC career interests in RPs. In reporting the results in this chapter, RPs were given pseudonyms that were inspired by the names of leading female African American AEC professionals such as Cheryl McKissack.

4.4.1.1 First Most Effective Component of fAEC-KLM – AEC and fAEC-KLM Lectures

The most effective component of the fAEC-KLM was the lectures on AEC and fAEC-KLM. These lectures exposed RPs to AEC concepts, salary benefits, underrepresentation of females especially African American females in AEC, success stories of African American female AEC professionals, etc. These lectures led to gain in knowledge as described in *sub-theme 1* and increased AEC career interests.

Sub-theme 1: Attributing to Gain in AEC Knowledge (N=6): Several studies show that the content of a lecture and life experiences have significant influence on student learning and interest (Baram-Tsabari & Yarden, 2005; Jones et al., 2000; Sjøberg & Schreiner, 2010). Knowledge gained refers to the additional knowledge that RPs received during the fAEC-KLM intervention. RPs ranked this knowledge gained from lectures as the most effective component of the fAEC-KLM in increasing their AEC interest. RPs highlighted the specific lecture sections that impacted their AEC interests.

a. **Attributing to Gain in AEC Knowledge on Intersectionality (N=4)**: RPs greatly valued the knowledge they received on the challenges that female African American AEC professionals have faced and how they have navigated through these challenges. Note-taking during the lectures helped RPs remember all the key points stated in the lectures. In response to the question, “how did the most effective component of the fAEC-KLM increase your AEC interest,” Norma explained:

> *"I think I think that they (AEC lectures) helped because they were teaching you more about the more about, more about AEC and females being in AEC and what they had to go through. So you know, like, if you had to go through something like they did, you know what situations, where like, what to do."*

RPs also attributed their AEC career interest to the knowledge gain on the underrepresentation of African American women in AEC. They placed themselves as problem solvers to reduce the workforce shortages and underrepresentation of African American females in AEC and serve as advocates for AEC enhancements as stated by Cheryl:

> *"I think, hearing the lack of representation in the field, and also hearing about the success stories and about the different beneficial opportunities in the career, because it's like for me, whenever I hear something, and it's like, there's not that many black people in this or not that many women of color, something, it always interest me more because you need more people to be interested in something. We need more representation. We need more people to see that you shouldn't just let a career pass you by, because it's not something you see yourself in literally. So I think that's what interested me more."*

The experiences of the RPs offer a compelling lens through which to examine Kimberlé Crenshaw's concept of intersectionality (Crenshaw, 1989; Crenshaw, 2013). Intersectionality posits that various aspects of social identity such as gender and race do not exist separately but are interwoven and mutually reinforcing. The underrepresentation of African American women in AEC served as a motivation to RPs and triggered the desire to serve as advocates for AEC enhancements.

b. **Attributing to Gain in AEC Technical Knowledge (N=2):** Lectures on types of bridges, forces acting on bridges, mathematical calculations on loads, and sustainable bridge materials increased RPs knowledge on these AEC-related terms as explained by Norma:

> *"The lectures helped me remember stuff more and also most definitely, when we learnt the math thing about dead loads and live loads, I think it helped."*

The findings indicate that the fAEC-KLM intervention was effective in enhancing RPs' knowledge of AEC concepts, particularly through targeted lectures on bridges, forces acting on and sustainable materials for bridges, and mathematical calculations for bridges. These lectures increased RPs' interests because it was different from their traditional school curriculum and had concepts not taught in traditional middle school classrooms. As seen by the statement made by Norma, these lectures served as knowledge retainment tools that created a more realistic sense in RPs of what they could learn about AEC, and this inspired interest.

c. **Attributing to Gain in Knowledge on AEC Outcome Expectations (N=2)**: Lectures on AEC salary benefits, a valuable outcome expectation, increased knowledge gain and subsequently their AEC career interests. RPs were taught through lectures on how much salary AEC professionals make and the benefits that come with being an AEC professional to include managing the construction of historical and astonishing buildings. These outcome expectations increase interest in AEC careers. As stated by Ann:

> ***"****The money they make has me interested."*

RPs emphasized the importance of pursuing a career that they will enjoy and pays well as it makes sense to them to get a well-paying job. Ann refers to wanting a well-paying job that will

cover the needs of her family and make her comfortable. Consequently, hearing that AEC offers such financial comfort increased her AEC career interest.

The AEC lectures impacted AEC career interests of RPs validating the study by Walan & Gericke (2021) that topics taught in an OST learning environment has great impact on learning and career interests. It is important to incorporate career-related lectures in middle school learning because it helps students understand the connection between their academic pursuits and their future careers which can lead to improved self-esteem, resilience, passion, strength, and confidence in pursuing their desired career-paths (McDermott et al., 2017; Yusoff et al., 2020).

4.4.1.2 Second Most Effective Component of fAEC-KLM – Bridge Construction

The second most effective component of the fAEC-KLM is the bridge construction project. The bridge construction project contributed to the self-efficacy and interests of RPs. The mechanisms through which the self-efficacy and interests of RPs in AEC careers are described in *sub-theme 2* below.

Sub-theme 2: Attributing to Gain in Self-efficacy (N=8): RPs also attributed their AEC career interests to self-efficacy gained through the bridge construction project components of the fAEC-KLM. Self-efficacy is a Bandura concept that simply means *"having an I can do it attitude"* (Bandura, 1994; Hackett & Betz, 1981; Ofori-Boadu et al., 2019). Self-efficacy gain occurred through different accomplishments.

a. **Attributing to Self-efficacy from Analytical Accomplishments (N=5):** Math abilities influence analytical accomplishments and impacted AEC career interest. After experiencing the AEC-related mathematical calculations within the fAEC-KLM, RPs with strong analytical abilities were convinced that their math abilities will help them succeed in AEC careers as expressed by Louise:

> *"I know I have like math skills and like I have, like the skill like needed to like make a problem and I can solve a problem. And to like it like that problem solving is like one of my major things. I like math, solving problem, problem solving and math and like live. I guess I help my friends like with their ideas and stuff."*

Louise's statement reflects the influence of intrinsic motivation on career interest. Her confidence in her mathematical abilities, combined with a passion for problem-solving, aligns with the key factors known to influence the development of self-efficacy (Hackett & Byars, 1996; Lent et al., 2000). Research suggests that math competence plays a significant role in determining students' career interests in STEM, particularly in engineering (Wang & Degol, 2017). These experiences from RPs underscore the importance of early exposure to real-world mathematical applications to build confidence and develop meaningful connections between classroom learning and career pathways.

b. **Attributing to Self-efficacy from Creative Accomplishments (N=4):** Engaging creative abilities in the bridge project within the fAEC-KLM impacted the AEC career interests of RPs. They were mostly excited to see their creativity being useful in their designs and construction of the bridge project. Brishae was asked how the bridge construction project impacted her AEC career interest, and she noted:

> *"It showed me that you can still be creative and have fun while working in AEC careers as well as being serious and hard working. And that definitely increased my interest."*

Although Brishae understands the seriousness of AEC careers, she still envisions the incorporation of her creative abilities and the enjoyment that she can derive from being an AEC

professional. The sense of accomplishment in Brishae's statement aligns with research showing that creativity in learning environments fosters engagement, personal investment, and career interest. The excitement RPs felt while integrating creative elements in engineering projects underscores how non-traditional approaches such as art-infused STEM activities can be highly effective in engaging underrepresented students.

c. **Attributing to Self-efficacy from Hands-on Accomplishments (N=4):** RPs expressed the impact the bridge design and construction project had on their AEC career interest. It highlighted their willingness to physically work on the construction of the bridge and succeed at tasks that they had not tried before as Hatti explained:

> *"The bridge construction showed me that, like a bridge, can't just look, like it has to be strong, and it has to put like a lot of work into it. It increased my interest a lot, because at first, I thought I didn't want like really anything to do with engineers and like building, but the camp kind of changed my mind. And now I know I can and I have more of an interest in doing it than I did before."*

Hatti placed emphasis on both the strength and aesthetics of the bridge. Her capacity to complete the project increases self-efficacy and then interest. Gaining self-efficacy from accomplishments within the fAEC-KLM highlights their appreciation of this learning style and how it engages them more actively in the learning process. The accomplishments they attained within the fAEC-KLM can be classified as mastery experiences. Mastery Experiences as described by (Bandura, 1999; Bandura, 2002; Bandura, 2006) are experiences gained from trying and succeeding at an activity or a challenge. Empirical studies have demonstrated the significant benefits of incorporating kinesthetic learning styles in middle school education, especially for students who may struggle with more traditional, lecture-

based instruction (Mobley & Fisher, 2014; Sulisawati et al., 2019). The importance of career-related kinesthetic activities cannot be overstated as they engage students more actively, cater to diverse learning styles, and provide a physical counterpoint to the growing trend of online education. Career-related kinesthetic learning has the potential to significantly enhance the academic, personal, and career development of middle school students. OST projects should be carefully designed to ensure that girls have reasonable time to complete their projects because interests depend on sense of belonging.

4.4.1.3 Third Most Effective Component of fAEC-KLM – Peer Interactions

The third most effective component of the fAEC-KLM is peer interactions. Peer interactions contributed to the sense of belonging and interest of RPs in AEC careers. *Sub-theme 3* narrates the mechanisms through which the fAEC-KLM impacted the sense of belonging and subsequent AEC career interest.

Sub-theme 3: Attributing to Gain in Sense of Belonging (N=5): RPs developed a sense of belonging being around other female African American middle schoolers, undergraduate students, and AEC professionals. Interacting with peers, sharing ideas, listening to stories from female African American professionals contributed to their career interests. These experiences can be classified as vicarious experiences. Vicarious experiences are gained from observing significant others such as peers or family (Bandura, 1999; Bandura, 2006; Hackett & Betz, 1981). RPs expressed the impact that vicarious experiences within the fAEC-KLM had on their AEC career interests.

a. **Attributing to Peer Support and Fun (N=3):** RPs valued the interactions they had with one another and mentioned it as another effective component of the fAEC-KLM. Interactions helped RPs know themselves better and also discuss lectures and AEC

related topics raised throughout the camp. This was an opportunity for them to make new friends with other African American middle school girls as Harris described:

> *"I mean, to think that it's kind of like you can meet new friends, when you're working in architecture to have to enjoy the time with, and all that other stuff, I feel like it kind of impacted the fact that like, oh, maybe this could be interesting to like meet these people. I don't know."*

RPs also attributed their AEC career interest to how fun AEC careers can. Through the fAEC-KLM intervention, they were able to experience a glimpse of what AEC careers can be like and they frequently associated fun with AEC careers as explained by Alesia:

> *"AEC seems like a really fine career option, even though I know it takes really a lot of dedication to do it. It seems really fun. And I get to do something that I love and no, I won't get bored, and I will like to do my job every day so AEC sounds really fun to do and really interesting."*

This aligns with Dryburgh (1999) who highlighted the need to balance work and play.

b. **Attributing to Observation of African American Female Role Models (N=2):** RPs were encouraged by the success stories of female African American AEC undergraduates and professionals who navigated through challenges and are now succeeding in their fields as explained by Nana:

> *"It was fun to see how Cheryl built like a whole company around what she likes to do, and I feel like that's probably something I like to do."*

RPs felt a connection with these role models and attributed their AEC career interest to wanting to be part of the solution to reducing the underrepresentation of African American in AEC as explained by Cheryl:

> *"For me, whenever I hear something, and it's like, there's not that many black people in this or not that many women of color, something, it always interests me more because you need more people to be interested in something. We need more representation. We need more people to see that you shouldn't just let a career pass you by, because it's not something you see yourself in literally. So I think that's what interested me more."*

Studies have shown that peer interactions and mentorship have both direct and indirect impacts on the academic performance, participation, and career interests of middle school girls (Ladd et al., 2014; Roberts et al., 2018). The existing research on the impacts of peer interactions for middle school girls is limited (Dabney et al., 2012). Most studies have relied on single-item surveys, which can limit the reliability and validity of the findings (Dabney et al., 2012; Saw et al., 2019). To address these limitations, further research with large sample sizes is needed to explore the specific and statistically significant mechanisms by which peer interactions in OST programs for African American middle school girls influence their AEC career interests.

Insights from this study highlight the importance of targeted kinesthetic learning interventions to increase the "I know" (knowledge), "I feel" (sense of belonging), and "I can" (self-efficacy) career-related self-description of African American middle school girls (Bandura, 2006; Hackett & Betz, 1981). It places the need to incorporate knowledge gain through lectures, mastery experiences through kinesthetic learning projects, vicarious experiences through gender and racial career-related learning and interactions in AEC OST programs. Insights are valuable because they increase understanding of how African American middle school girls experience and make meaning of AEC-OST engagements through the fAEC-KLM. They also inform the tailored design and development of OST programs to increase AEC career interests and in the

long term improve the representation of African American women and reduce workforce shortages in AEC careers (Boone, 2016; Gonzales, 2014).

The findings of this study emphasize the pivotal roles that the gain in AEC knowledge, sense of belonging, and self-efficacy play in shaping students' career interest. For knowledge, lecture contents should be rich, detailed, and practical, connecting discipline relevant theoretical concepts with real-world examples. This ensures that students can relate learning content to their daily lives, sparking curiosity and career interests (Walan & Gericke, 2021). Regarding sense of belonging, peer interactions and role models are especially important for African American middle school girls. The opportunity to learn alongside peers who share similar racial and gender backgrounds and interests, coupled with the presence of successful African American female role models, provides strong encouragement to pursue careers, particularly in underrepresented fields like AEC (Gibson, 2004; Quimby & De Santis, 2006). Studies indicate that when young girls see individuals like themselves thriving in STEM careers, it significantly enhances their motivation to follow similar paths. Self-efficacy – the belief in one's ability to succeed or the "I can do it" attitude – is a crucial factor in determining career interest. According to (Bandura, 2006), self-efficacy acts as the driving force behind career aspirations. Therefore, activities that build self-efficacy, such as hands-on, kinesthetic learning projects, should be integrated into OST interventions. In this study, hands-on projects positively impacted students' self-efficacy, reinforcing their belief that they could succeed in AEC careers. These findings are in alignment with existing literature of AEC career knowledge, understanding, self-efficacy, and interest development in African American middle-school girls through AEC-infused OST programs (Ofori-Boadu et al., 2019; Ofori-Boadu, 2018; Luster-Teasley et al., 2016).

4.4.2 Wilcoxon Signed-Rank Test on Surveys:

Results of the Wilcoxon Signed-Rank test indicated no significant difference between the rankings of fAEC-KLM model components in the pre-survey (Mdn = 10.3, n = 20) and post-survey (Mdn = 10.3, n = 20), W+ = 107, p = 0.956, r = 0.01. Despite the lack of statistical significance, the ranking results revealed an interesting shift in participant perceptions regarding the most effective components of the fAEC-KLM. Initially, RPs ranked teamwork, interactions, lectures, and female African American success stories the most effective components. However, post-survey rankings showed a marked shift, with RPs identifying kinesthetic, teamwork, and female African American success stories as the most effective components for increasing their interest in AEC career. Notably, the mean ranking of female African American success stories reduced from 9.38 to 7.07, showing improved perception of effectiveness.

The shift highlights RPs' growing appreciation and effectiveness of kinesthetic learning activities as marked by improvements in AEC career interests. Research suggests that kinesthetic learning can significantly enhance understanding and retention of material compared to traditional lecture-based methods (Califf, 2020; Mobley & Fisher, 2014). The RPs' post-survey preference for kinesthetic activities aligns with the theory of experiential learning proposed by (Kolb & Kolb, 2009), which emphasizes the importance of concrete experience in the learning process.

Table 5 shows the top and bottom six effective components for both pre- and post-survey.

Table 5. *Top and Bottom Six Effective Components of the fAEC-KLM*

Top six (6) Most Effective Components of fAEC-KLM				**Bottom six (6) Most Effective Components of fAEC-KLM**			
Pre-survey		**Post-survey**		**Pre-survey**		**Post-survey**	
Activity	**Mean Rank**	**Activity**	**Mean Rank**	**Activity**	**Mean Rank**	**Activity**	**Mean Rank**
Teamwork*	3.85	Bridge Design	5.79	Lecture on salary benefits of AEC professionals	13.00	Interaction with Instructors	12.43
Lunch	5.62	Bridge Construction	6.14	Incorporation of feminine products to project design and construction	13.54	Response to questions asked	14.50
Interaction with peers**	6.46	Lunch	6.29	Response to questions asked	14.08	Classroom setting	14.79
Interaction with teammates***	7.54	Teamwork	6.71	Interaction with undergraduate panelists	14.08	Awards ceremony	15.36
Lecture on bridge design and construction	9.38	Lecture on bridge design and construction	7.00	Lecture on self-efficacy and identity	14.69	Interaction with undergraduate panelists	16.79
Documentary of successful female African American AEC Professionals	9.38	Documentary of successful female African American AEC Professionals	7.07	Awards ceremony	14.77	Lecture on self-efficacy and identity	17.50

*Teamwork: RPs were placed in teams of two. Teamwork refers to the pairs working together on the project or a given task within the fAEC-KLM.

**Interaction with peers refers to discussions with other RPs within the fAEC-KLM.

*** Interaction with teammates refers to discussions between paired RPs.

Comparing responses from interviews and surveys, the bridge construction projects is the common most effective fAEC-KLM component emphasizing the importance of kinesthetic learning in increasing AEC career interests in African American middle school girls. Also, lectures and female African American professionals' success stories increased career interests.

4.5 Research Question 2: ***How do salient identities of African American middle school girls interact with learning experiences in the fAEC-KLM?***

4.5.1 Interview

Results from responses to the interview question asking RPs about the important aspects of themselves that interact with their learning experiences in the fAEC-KLM to contribute to their AEC career interests, show that RPs had predispositions that influenced their career relevant and non-career relevant identities and interacted with their AEC learning experiences.

4.5.1.1 Career relevant identities

These are self-meanings that RPs considered important to their career aspirations. They believe that possessing specific abilities and self-meanings will enhance the possibilities of being successful in their future careers.

a. ***Analtyical Identity (N=8):*** RPs expressed that their possession of salient mathematical and problem-solving self-meanings will help them succeed in their future careers as expressed by Louise:

   "I know I have math skills and like I have the skills needed to make a problem and solve a problem… problem solving is one of my major things… I guess I help my friends like with their ideas and stuff…"

   RPs with salient analytical self-meanings exhibited analytical problem-solving learning experiences within the fAEC-KLM, including, coming up with design ideas,

calculating forces acting on bridges, and figuring out the best materials to build a strong bridge. This finding is in alignment with Ofori-Boadu et al (2020) and Ofori-Boadu & Ofori-Boadu (2022) which highlight the importance of analytical abilities in career interest development in undergraduate AEC women.

b. ***Creative Identity (N=3):*** RPs expressed that their possession of salient creative self-meanings contributed to their engagement in learning experiences within the fAEC-KLM as described by Norma:

> *"I am creative, and I love to draw. ...loving to draw is one thing too, because if you love to draw, that can help with the sketches and stuff like that."*

Norma indicated that creativity was important to her career aspiration. Her creative ability was expressed when Norma was developing designs and making decisions on the best materials for the bridge construction project. RPs with career-relevant creative abilities appeared more comfortable with the bridge design and construction project. They excelled at knowing how best to place materials together to make strong bridges and also come up with supporting stories to go along with their bridge designs. This finding is in alignment with Ofori-Boadu et al (2020) and Ofori-Boadu & Ofori-Boadu (2022) which highlight the importance of creativity in career interest development in undergraduate AEC women.

c. ***Social Identity (N=3):*** RPs expressed that the possession of social self-meanings such as being good listeners, speaking, leading, and interacting with others were most relevant to their career aspirations as stated by Cheryl:

"...the most important is that my public speaking skills cause I feel like I do really well in front of a crowd, or just in front of a large group of people, and that I feel like really well talking about my viewpoints, my ideas."

RPs with this ability succeeded at sharing ideas and views, as well as making new friends and interacting better with other girls in the camp. They were good at asking questions and expressing themselves throughout the fAEC-KLM intervention.

4.5.1.2 Non-career relevant identities:

a) ***Math Identity(N=14):*** RPs considered math identity as important in learning experiences but not to their career aspirations. They prioritize other identities over math identity.

   i) ***High Mathematical Identity (N=11):*** These RPs have good math abilities. They believe being good in math improves their chances of becoming AEC professionals. They exhibited strong mathematical abilities during the bridge calculations for the bridge construction project. However, they do not prioritize these math abilities in their career aspirations.

   ii) ***Low Mathematical Identity (N=3):*** These RPs do not like math and are not good in math. For Sunny, she previously liked math but that changed during the COVID-19 pandemic when math was taught in digital environments that disrupted her learning as explained:

   "Yeah, it's because in elementary school I liked math, but after, like Covid and stuff in sixth grade, I didn't learn much because it, it was all zoom. I can't really learn that way."

Sunny highlighted that having this deficient math pedagogy impacted her learning experiences within the fAEC-KLM as she fell behind on some of the math tasks. On the other hand, Harris has never liked math and expressed that she never will, which prevented her from participating in the math calculations within the fAEC-KLM as she noted:

> *"...the main part of architecture that you really need in there is math calculations, and that part, it really brought it down even more for me, because I don't like math, I hate it, will never like it."*

4.5.2 Mean Ranks of Salient Identity Statements in Surveys

Results of pre- and post-survey analysis on salient identities or self-attributes and how they interact with the learning experiences of RPs revealed several interesting patterns that shed light into how the fAEC-KLM interacts with the salient identities of African American middle school girls. Self-attributes are behaviors, abilities, and unique characteristics that entail how a person views themselves (Choy & Yeung, 2022; Rusu et al., 2015). Table 6 below summarizes the changes in mean ranks of salient identity responses in pre- and post-surveys.

Table 6. *Changes in Mean Ranks of AEC Salient Identity Statements*

	Pre	**Post**	**Change**
I enjoy…			
Working with peers on AEC projects	3.58	4.00	+0.42
Problem-solving	3.58	3.83	+0.25
Being inspired by African American females	3.75	3.91	+0.16
Being inspired by female AEC role models	3.75	3.50	-0.25
Observing objects in my environment	3.92	3.67	-0.25
Being creative	4.50	4.17	-0.33
Hands-on projects	4.50	4.00	-0.50

Salient identities that had positive interactions within the fAEC-KLM were related to collaboration, problem-solving, and intersectionality.

a. *Collaborative identities*: The most substantial positive change was in working with peers on AEC projects (+0.42). This aligns strongly with communal values and intersectional engagement pedagogies (Boykin & Noguera, 2011) pertaining to the African American culture. The fAEC-KLM appears to be successfully nurturing a collaborative identity within the AEC concept, which can be a powerful tool for engaging and retaining underrepresented groups in STEM fields (Denson et al., 2010).
b. *Problem-solving identities*: There was a notable increase in *enjoyment of problem-solving* (+0.25). this positive change aligns well with the development of a STEM identity among African American girls, as discussed by (Tan et al., 2013). Problem-solving abilities are an important skill in AEC careers, and the increase suggests that RPs are beginning to see themselves as capable problem-solvers. This could be leveraged to address challenges in other areas, potentially using culturally relevant scenarios or community-based projects to further strengthen this identity (Basu & Barton, 2007).
c. *Female and African American Identities (Intersectionality)*: Inspiration from African American females increased (+0.16) suggesting developing a stronger identity connection with role models who share both their gender and racial background. The fAEC-KLM could further strengthen this by increasing exposure to African American women in AEC fields, as supported by research on the importance of same-race role models. Also, connecting AEC concepts to community development can help facilitate the association female and African American identities with AEC careers (Barton & Tan, 2010; Stout et al., 2011).

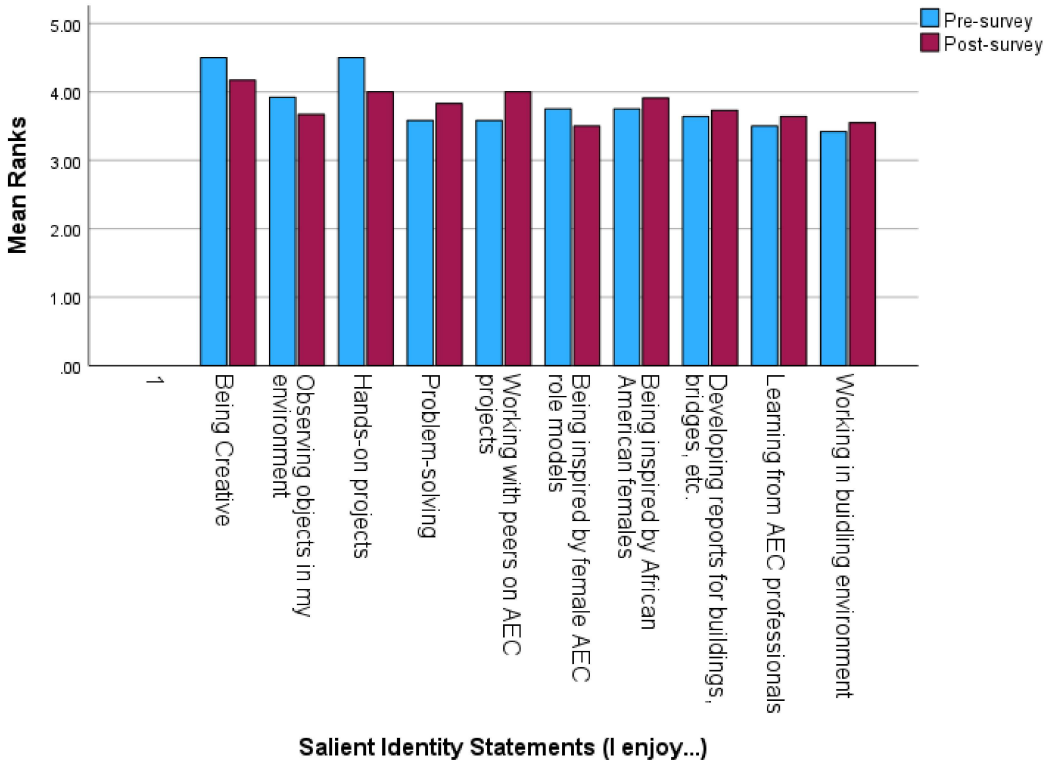


Figure 11. Changes in Mean Ranks of Salient Identity Statements

Figure 11 above shows the comparisons of mean ranks for salient identity statements in pre- and post-surveys. There is no statistically significant difference between pre-survey mean ranks (M =3.81, SD=0.39) and post-survey mean ranks (M=3.80, SD=0.22), t=0.15, p=0.89, however, post-survey mean ranks show that RPs related more with their problem-solving, collaborative, intersectionality, and kinesthetic self-meanings with learning experiences.

These findings suggest that the fAEC-KLM interacts with RPs' identities, particularly with race and gender identities. However, there are opportunities to better support creative and observational identities by integrating more culturally relevant activities.

The results underscore the importance of considering the multifaceted nature of identity – including cultural (race), gender, socialization, and problem-solving – in designing AEC-OST education programs for underrepresented groups (Hazari et al., 2013). By aligning learning

experiences more closely with the salient identities of African American middle school girls, the fAEC-KLM program can potentially increase its effectiveness in nurturing sustained interest in AEC fields and contributing to greater diversity in these professions. The impact these career-relevant identities have on AEC career interests are further explained in *research question 3*.

4.6 Research Question 3: *To what extent does the fAEC-KLM impact AEC career knowledge, self-efficacy, outcome expectations, and interests in African American middle school girls?*

Surveys, tests, interviews, and observation were used to understand the extent to which the fAEC-KLM impacted AEC career-related knowledge, self-efficacy, outcome expectations, and interests.

4.6.1 fAEC-KLM Impact on AEC Knowledge

4.6.1.1 Thematic Analysis of Interviews:

To identify the impact the fAEC-KLM has on the AEC knowledge of RPs, responses from two interview questions provided insight.

1. *"Tell me what you know about female and African American participation in AEC careers?"*

In the pre-interview, RPs' responses demonstrated a clear lack of foundational or sufficient knowledge about AEC careers, particularly regarding the representation of women, especially African American women, in these field. Before the fAEC-KLM intervention, 93% (N=13) of the RPs admitted to having little to no awareness of female or African American participation in AEC careers. Only one participant, Brishae, showed some awareness of the underrepresentation of African American women in AEC stating:

> *"Well, I don't know much, but from like the stories we've heard and well, for instance like hidden figures and stuff. I just, I kind of realizing like these jobs, um*

African Americans, especially females, they're kind of put to the back, and they're not really like being shown or represented as much. But they most definitely like work as hard as the others and should be more represented."

Brishae's knowledge stemmed from informal sources, such as movies, rather than formal education. This suggests that schools generally do not integrate adequate education about the contributions and representation of women and African Americans in certain STEM fields into their curricula.

However, after the fAEC-KLM intervention, RPs' post-interview responses revealed a significant shift. All RPs (100%) demonstrated a clear understanding of the involvement of women and African Americans in AEC careers, highlighting the effectiveness of the intervention in bridging the initial knowledge gap around gender and racial participations in AEC fields as stated by Louise:

"I know there's not a lot of females that take part in it. I guess they feel like it's a male dominated area. But it kinda like feels they won't be respected in that area. People don't take them seriously."

Harris went further to provide statistics based on the AEC lectures received during the summer camp by saying,

"Well, I learnt that like, there's a very small amount of women in construction, in architecture like very small. There's like 23% of women in architecture in general like not even like African America-wise, in general. Whatever we share, African American women is like 9%, right? I was just very blown away by the fact that mainly in like the industry field, that they're just mostly men. At the same time, I'm not very surprised, but I have a feeling that if women were to be interested in

AEC, it would be to be the architect, like, you know, to be the one to draw the design and stuff. I don't see much of women going into construction if they were to join but you know it's just a personal opinion. I don't know. Maybe just because of the way I think women are. They would prefer not to get their hands dirty a lot. I also learned that there were a lot of important women that made a impact on architecture that most people don't really know about. So that's kind of sad. But you know."

The response made by this Harris shows that although the AEC lectures helped improve the knowledge of female and African American participation in AEC careers, more work needs to be done as she still believes that there are certain AEC careers that females will thrive better in than others. However, it can be seen that the fAEC-KLM made major impacts on the AEC knowledge of the RPs as can be seen by comparing the limited responses they had in the pre-interviews with the more developed knowledge displayed in the post-interviews.

2. *"On a ranking scale of 1 (lowest) and 5 (highest), to what extent do you think you have the knowledge needed to make a decision about pursuing an Architecture, Engineering, and Construction (AEC) career? Explain how lived and learning experiences have contributed to your rank."*

The pre-interview responses reveal that RPs' prior knowledge of AEC careers was limited and often based on misconceptions. Many RPs conflated AEC, particularly engineering, with computer science, robotics, and coding due to previous experiences in STEM camps and school classes. Their attributed sources of AEC knowledge included summer camps, personal experiences, family members or role models, and school classes. Additionally, some RPs associated their understanding of AEC with gendered peer interactions in school, particularly

noting the underrepresentation of girls in engineering-related classes. These findings highlight a significant gap in accurate AEC knowledge among African American middle school girls prior to the fAEC-KLM intervention, underscoring the need for targeted educational programs that provide clear, accurate information about AEC careers and kinesthetic experiences in these careers.

In post fAEC-KLM intervention however, all RPs showed more knowledge on AEC than they did before interacting with the fAEC-KLM. They attributed the gain in knowledge on AEC careers to effective interactions within the fAEC-KLM to include lectures.

a. ***Lectures on Female African American Underrepresentation (N=7):*** Well-structured lectures can be effective in transmitting complex information (Walan & Gericke, 2021). According to RPs, the AEC lectures had the most impact on their AEC knowledge within the fAEC-KLM. Not only did they appreciate the lectures, but they also emphasized how note taking during the lectures also helped them retain what they learnt. An example is a statement made by Norma:

> *"The lectures most definitely did. I ended up taking notes. It helped me remember stuff more."*

Another statement by Brishae also verifies that there was knowledge gain from AEC lectures on the underrepresentation of African American females in AEC:

> *"I would say the lecture on the AEC females or African American females gave us a bunch of like knowledge, background knowledge on AEC and what its about and also the important role models."*

The exposure to role models addresses the need for women of color in STEM to see themselves reflected in the field as discussed by Tan et al. (2013). The statements

made by these RPs on the impact of the AEC lectures verify Walan & Gericke (2021) that the content of a lecture or a topic being taught is important to stimulating career interest in STEM subjects. The effectiveness of lectures in the fAEC-KLM may have been enhanced by their integration with other active learning modalities such as note-taking and applying the knowledge gained.

b. ***Bridge Design and Construction (N=6):*** The kinesthetic bridge design and construction project was a significant contributor to knowledge gain, exemplifying the principles of experiential learning theory described in Kolb (1984). RPs described how the kinesthetic bridge design and construction project impacted their AEC knowledge. An example is a statement made by Beverly:

> *"I feel like the bridge design and construction project was important, because it taught us how people in AEC like use their teamwork and what struggles they have to go through, and how much time and dedication they have to put into their projects for it to work, and for their projects to be successful and help the society."*

This aligns with findings from Calabrese Barton & Tan (2018), emphasizing the importance of kinesthetic learning in engaging underrepresented youth in STEM. Kinesthetic learning opportunities do not only develop technical abilities but also proven -solving abilities and engineering mindsets and this can be seen in a statement made by Nana:

> *"Building the bridge kind of increased my knowledge because it was like cause and effect. So, like if something didn't work, we had to either redo it or figure out*

a new solution to make it work and we never really gave up because we couldn't give up. We just had to keep trying to fix the bridge."

These statements made by RPs give deeper insights into the impact the fAEC-KLM had on their AEC knowledge.

c. ***Lecture on Bridge Design and Construction (N=6):*** The lectures on bridge design and construction also gave RPs insight and the relevant knowledge to build their preferred designs.

"I would say the lecture on the bridge construction and the different types of bridges gave us like a bunch of like knowledge and that helped us build the bridge." - Norma

The effectiveness of lectures in the fAEC-KLM may have been enhanced by their integration with other active learning modalities such as note-taking and RPs mentioned throughout that taking notes during the lectures helped them retain the information better. Deslauriers et al. (2019) describes lectures as being particularly effective when they provide a framework for subsequent kinesthetic activities.

d. ***Peer Interactions (N=3)***: Many RPs highlighted the value of interacting with peers and discussing what they learned, reflecting the principles of social constructivism in education (Rodriguez, 1993). They appreciated that they could interact with their peers, discuss what they learnt and share ideas among themselves as explained by Sunny:

"I really like the interaction with other people because we got to like, discuss what we're gonna do and discussed what we learned a bout in camp."

Loraine also highlighted that peer interaction her knowledge and heightened her sense of belonging as described:

> *"Hanging out with other girls increased my knowledge by kind of being able to see the perspective of women that work in AEC careers, it kind of made me think about like... Hmm! I'm standing in a room, in like the room full of girls instead of a room full of men. So, it kind of made me see my perspective on things and stuff like that."*

She compared male and female interactions and connected more with women perspectives. Same gender peer interactions are particularly beneficial for underrepresented groups in STEM. As noted in the study by Ong et al., (2018), peer interactions and community building are crucial factors in the persistence of women of color in STEM fields.

RPs were also required to self-rank their AEC knowledge in the pre- and post-interviews. Self-rankings were categorized into three groups: (1) Increased AEC knowledge ranking; (2) Maintained AEC knowledge ranking; (3) Decreased AEC knowledge ranking.

i) ***Increased AEC knowledge ranking (N=9):*** Fifty-seven percent (57%) of RPs increased their self-rankings of AEC knowledge from mid (3) in the pre-interview to high (4 or 5) in the post-interview and seven percent (7%) increased from low (1or 2) to mid (3). They justified their rankings by highlighting that they now believe that they know more about AEC because of the fAEC-KLM intervention.

ii) ***Maintained AEC knowledge ranking (N=3):*** Twenty-one percent (21%) of RPs maintained the same knowledge rankings (high – high) in both pre- and post-interviews. Despite learning more about AEC during the fAEC-KLM intervention,

these RPs had high rankings in the pre-interview due to misconceptions that equated prior engineering knowledge to AEC knowledge. With their new understanding, they felt there was no higher rank available on the scale provided in the interviews.

iii) ***Decreased AEC knowledge ranking (N=2):*** Fourteen percent (14%) of RPs ranked their AEC knowledge as high (5) during the pre-interviews but lowered ranking to mid (3) in the post-interview. This decrease in ranking was not due to reduced knowledge but rather a more realistic assessment of their knowledge. After participating in the summer camp, these RPs recognized that they still had much to learn and that the five-day camp could not cover all aspects of AEC.

The fAEC-KLM intervention appears to have been effective in increasing AEC knowledge in many RPs. Sixty-four percent (64%) reported an increase in knowledge, while 21% maintained their already high rankings. The apparent decrease in rankings for 14% of RPs actually reflects a more nuanced understanding of the field's complexity. These results suggest that the fAEC-KLM intervention not only improved RPs' AEC knowledge but also helped them develop a more accurate perception of the breadth and depth of AEC careers. The fAEC-KLM seems to have been particularly effective in correcting initial misconceptions about the scope of engineering within the AEC domain.

However, the study also highlights the limitations of short-term interventions. Some RPs recognized that a five-day summer camp, while informative, could not provide comprehensive coverage of the entire AEC field. This realization led to more conservative self-rankings in the post-interviews.

Future research could explore the long-term impact of such interventions and investigate ways to provide more comprehensive AEC education within time constraints. Additionally,

developing a more granular ranking system might help capture subtle changes in RPs' AEC knowledge and perceptions more accurately.

4.6.1.2 Paired-Sample T-test on Surveys.

Results from paired-sample t-test on surveys show significant difference in knowledge before fAEC-KLM (M = 3.50, SD = 0.31) and after fAEC-KLM (M = 3.99, SD = 0.34); t = -3.94, p = 0.0076. Before exposure to fAEC-KLM, RPs had misconceptions that led them to associate the engineering in AEC understood engineering in AEC professions related to robotics and coding. The fAEC-KLM exposed them to detailed knowledge about AEC professions.

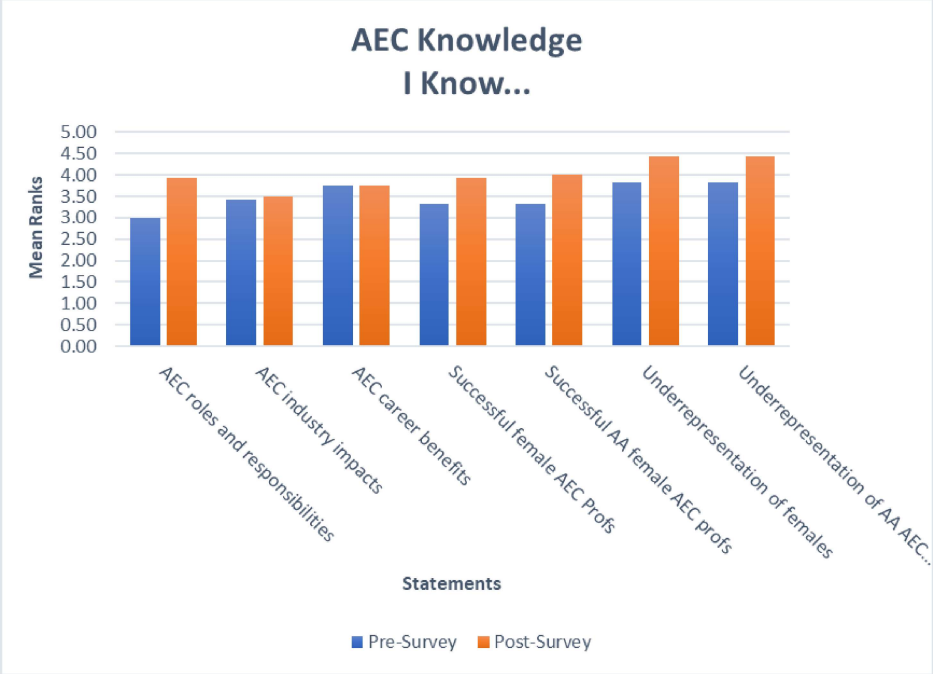


Figure 12. Mean Ranks of AEC Knowledge Statements

Figure 12 above shows that through the fAEC-KLM, RPs' AEC knowledge increased on all measured aspects except for AEC career benefits. This shows that the fAEC-KLM was impactful in creating awareness and increasing the knowledge of AEC in RPs. Through the fAEC-KLM, RPs had the opportunity to learn on the different aspects of AEC including roles

and responsibilities of AEC professionals, the underrepresentation of African American women in AEC and other important information about AEC.

4.6.1.3 Paired-Sample T-test on Tests.

Results from pre- and post-test show statistically significant difference in AEC knowledge before fAEC-KLM (M = 5.13, SD = 4.43) and after fAEC-KLM (M = 8.50, SD = 3.31); t = -5.03, p = <0.001. Pre-test responses confirm that RPs knew little to nothing about AEC roles and responsibilities, industry impacts, female and African American representation in AEC. Post-tests, however, recorded increased knowledge of AEC concepts with RPs having an increase in correct test answers.

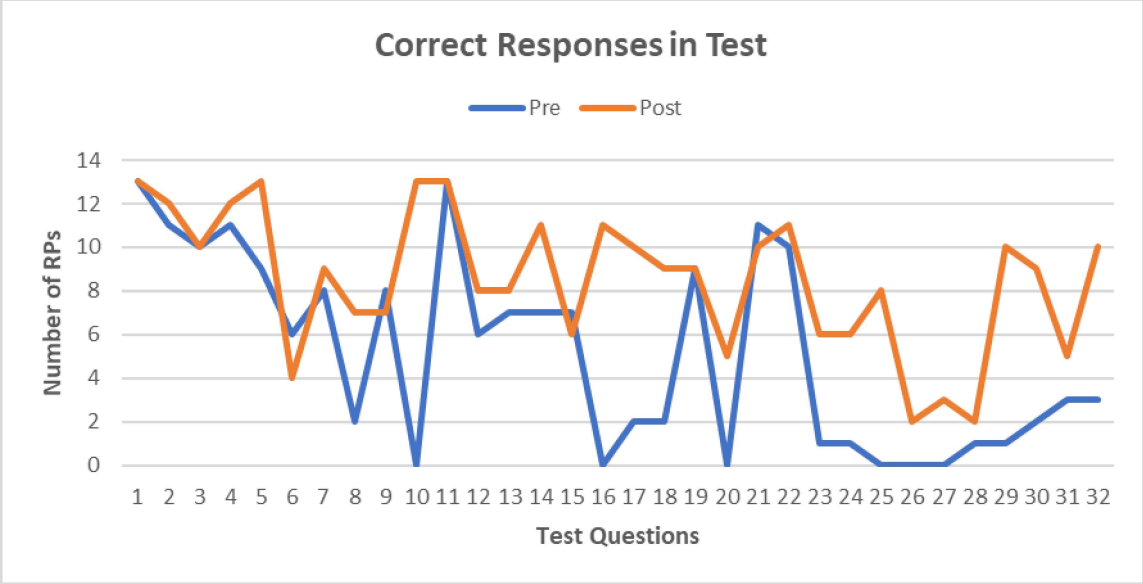


Figure 13. Pre- and Post-test Responses

Figure 13 highlights the increase in post-test scores for all thirty-two (32) questions. Questions were also grouped into AEC roles and responsibilities, AEC intersectionality, AEC salary benefits, and other AEC concepts to compare RPs' AEC knowledge pre- and post-

intervention. As shown in *Figure 14*, there was a statistically significant difference in mean test scores for pre-test (M = 0.3, SD = 0.28) and post-test (M = 0.48, SD = 0.26); t = -3.4, p = 0.01.

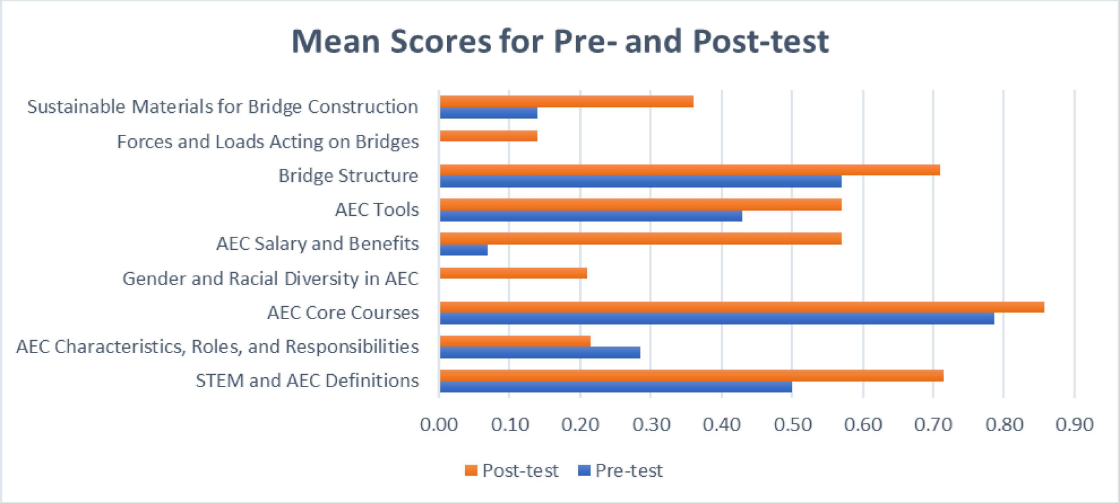


Figure 14. Mean Scores for Pre- and Post-tests

The fAEC-KLM's multifaceted approach to increasing AEC knowledge aligns with best practices in STEM education, particularly underrepresented groups. The combination of theoretical knowledge, practical application, and gender/cultural relevance reflects the principles of situated learning theory which emphasizes the importance of learning in context (Lave, 1991).

The fAEC-KLM's emphasis on peer interaction and discussions facilitates communities of practice as described in (Wenger, 1999) which are crucial for developing career identities in STEM fields such as AEC. For African American middle school girls, these communities can provide much-needed support and validation. Also, the inclusion of female AEC professionals, especially African American women, as role models addresses the critical need for perceived similarity (Herrmann et al., 2016) between students and AEC professionals. These can significantly impact girls' ability to envision themselves in AEC careers and reduce underrepresentation. The fAEC-KLM's encouragement of gender and culturally relevant kinesthetic, active, and experiential learning strategies aligns with the interactive, constructive,

active, and passive (ICAP) framework (Chi & Wylie, 2014) which posits that more engaged mode of learning lead to better outcomes. By incorporating multiple modes of engagement, the fAEC-KLM maximizes learning potential.

4.6.2 fAEC-KLM Impact on Self-Efficacy

4.6.2.1 Thematic Analysis of Interview

Pre-interview responses indicate that the pre-intervention self-efficacy RPs had towards AEC careers was influenced by determination to excel at any task, interest in kinesthetic activities, prior exposure to OST learning such as summer camps, having a family member who is an AEC professional, and exposure to precollegiate engineering education. Some RPs also highlighted the presence of low pre-intervention AEC self-efficacy and attributed this to having deficient mathematical pedagogy, meaning that they did not have adequate access to math education. However, post-interview responses highlight the impact of the fAEC-KLM and its components on the AEC career self-efficacy of African American middle school girls.

a) **AEC Understanding (N=7):** RPs attributed their AEC self-efficacy to their increase in knowledge on AEC-related concepts and to them now having a better understanding of what AEC entails. This increased their confidence in becoming future AEC professionals. Norma confirmed this by saying:

> *"The bridge design, like it helped me know that I can well, I can do whatever I set my mind to and the lectures helped me understand."*

The lectures also helped the RPs understand that their gender and underrepresentation should not be a liability. Rather it is important for them to know that they can do anything they set their minds to as expressed by Norma:

> *"...the lecture we had about being confident and saying I can do it, I think that it helped my confidence a little bit because if I thought like, usually, I don't like being the only girl doing something. So I think it increased my confidence a little bit by having a lecture about being able to do stuff and being confident and saying that, you're saying that you can do something."*

b) ***Self-belief (N=6):*** For some RPs, the fAEC-KLM reaffirmed the belief that they have in their own capacity to be successful. They attributed their post-intervention AEC self-efficacy to their determination and self-encouragement to succeed as stated by Bridget:

> *"I can actually do anything that I want to do."*

c) **Role-modeling via Intersectionality (N=4):** These RPs believe that since the few female African American AEC professionals they were taught about were successful, they can also succeed at being female AEC professionals as explained by Bridget:

> *"Because I would be another African American female in a career where it's not a lot, and I'll probably be pretty successful because a lot of the African American females that are in the careers are successful. So, if I would just take inspiration from them, I could be successful just like them."*

They received the inspiration needed to thrive as a female in male-dominated careers.

d) ***Kinesthetic Learning (N=4):*** These RPs attributed their AEC self-efficacy to completing the kinesthetic activities within the fAEC-KLM as described by Cheryl:

> *"...after our bridge winning, that kind of boost my confidence a lot because it showed that some ideas that I could have could be like really successful like this actual point."*

Cheryl's team won the prize for best bridge at the summer camp and this accomplishment boosted her self-efficacy.

The self-assessment of AEC self-efficacy completed by RPs shows that the fAEC-KLM intervention had a positive impact on the AEC self-efficacy of the majority of RPs. Seventy-eight percent (78%) of RPs either increased their self-efficacy or maintained a high level of self-efficacy. This suggests that the fAEC-KLM was effective in boosting the AEC-relevant "I can" confidence in African American middle school girls.

4.5.2.2 Paired-sample T-test on Survey.

Results from the t-test indicate that there is no significant difference between AEC self-efficacy before fAEC-KLM (M = 3.83, SD = 0.24) and after fAEC-KLM (M = 3.94, SD = 0.32); t = -1.01, p = 0.34). Self-efficacy was interpreted to the RPs as "I can do it attitude." There is no significant difference in the responses to self-efficacy statements because some RPs had already rated self-efficacy high in pre-surveys prior to engaging with the fAEC-KLM which also buttresses the limitations of Likert scale method (Jebb et al., 2021; O'Neill, T. A., 2017).

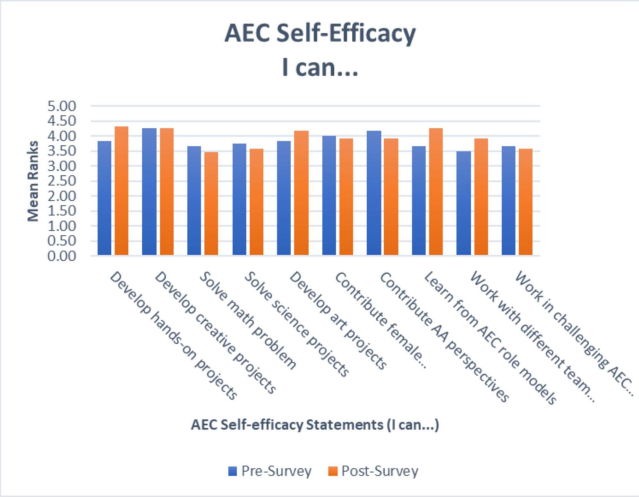


Figure 15. Mean Ranks of AEC Self-efficacy Statements

Kinesthetic and hands-on learning experiences emerged as key AEC self-efficacy impactors. The bridge-building activity, in particular, was frequently mentioned as a confidence-boosting experience. This underscores the importance of practical, engaging activities, in AEC education programs (Kolb & Kolb, 2009) and aligns with Bandura's emphasis on the importance of mastery experiences in developing self-efficacy beliefs in careers. The kinesthetic activities of the fAEC-KLM appear to have provided such mastery experiences, contributing to increased self-efficacy.

The positive impact of the exposure to successful African American female AEC professionals supports Lent's social cognitive career theory, emphasizing the importance of role models in shaping career interests and self-efficacy. Exposure to female AEC experts increased self-efficacy and career aspirations among female students (Stout et al., 2011). The fAEC-KLM intervention's success in this area underscores the importance of female and African American representation in AEC outreach programs for African American middle school girls.

The relationship between increased knowledge about AEC professions and higher self-efficacy aligns with Bandura's cognitive social learning (Bandura, 2006; Hackett & Betz, 1981). As RPs gained more accurate information about AEC careers, their self-efficacy was strengthened. Kinesthetic interventions can significantly impact AEC self-efficacy among adolescents. The success of the fAEC-KLM intervention highlights the importance of comprehensive career information in AEC outreach programs.

The role of positive peer interactions in boosting self-efficacy aligns with the concept of vicarious experiences in Bandura's (1994) self-efficacy theory. Observing peers succeed in AEC-related tasks likely contributed to RPs' belief in their own capabilities and encouraged them to develop soft skills such as socializing with peers.

> *"I feel because during the camp I, on my very first day I felt very, very shy, and I didn't really kind of make a lot of friends even not only like made friends with them, my table group. It still kind of pushed me to like learn how to make friends with people I'm unfamiliar with and work with people I'm not familiar with so I think it kind of pushed me out of my comfort zone to like try to get to know the people around me, now I can interact with others better." (Loraine)*

This finding is consistent with Ladd et al. (2014), who found that peer support significantly predicted STEM persistence intentions among minority students. The collaborative nature of the fAEC-KLM intervention appears to have fostered such peer support, contributing to increased self-efficacy.

The increased motivation due to awareness of underrepresentation aligns with stereotype inoculation model (Dasgupta, 2011), which posits that exposure to in-group experts can help minority students resist negative stereotypes. Making diversity visible in STEM can increase sense of belonging and motivation among underrepresented students (Shin et al., 2016). The fAEC-KLM intervention's success in this area suggests that openly discussing underrepresentation can be a powerful motivator when combined with exposure to successful role models.

The persistence of low self-efficacy in some RPs aligns with the concept of self-efficacy as a domain-specific construct (Bandura, 1999). For some, the intervention may have clarified that AEC careers do not align with their interests nor perceived strengths.

> *"They camp showed me that I have no count like that, I have first of all, what's the word? I have, No, I forgot the word. I actually changed my idea twice. No, once, when I was building the bridge. Building the bridge showed me that I can never*

be an architect. It also showed me that I could never be in construction, because the idea that we had on the paper we were initially going to do we would like line up the wood and everything right. It did not work out because I had a feeling it was going to be too small." (Harris)

This finding underscores the importance of considering individual differences in STEM interventions, as highlighted by Lent et al. (2018) in their social cognitive career theory. Future interventions might benefit from more personalized approaches that consider individual interests and aptitudes. Nevertheless, the fAEC-KLM also revealed to a few RPs that AEC is not an option. This early understanding can prevent future struggles in undergraduate education and careers that may not be a good fit.

4.6.3 fAEC-KLM Impacts on Outcome Expectations

4.6.3.1 Thematic Analysis of Interview

Pre-intervention interview responses on AEC outcome expectations show that RPs had no knowledge of the benefits of AEC careers, which made it difficult for them to describe the benefits AEC careers can provide them. However, post-intervention interview responses revealed the vast awareness of AEC benefits. The perceived benefits of pursuing AEC careers as expressed by RPs are detailed below.

a) ***Financial benefits (N=12):*** Majority of RPs appreciated the good salary benefits of AEC careers and highlighted it as one of the benefits they anticipate should they become AEC professionals as stated by Brishae:

“I’ve learned that it pays really well, and then, and that’s always a great benefit…”

RPs highlighted the good salary benefits as a reward for going through the necessary college years to be an AEC professional. Nana said:

"It made me want to do it a little bit more… After you go through those years of college and you get straight into it, you could start working towards that high paid money."

b) ***Community Impacts (N=5):*** RPs highlighted the consistent knowledge they will gain from being AEC professionals and how this knowledge can impact their communities as explained by Cheryl:

"…seeing everything that you can accomplish, and how beneficial it can be. And it can be something as big as like a bigger project or something as developing a certain type of sidewalk for everybody. Like you can benefit in lots of different ways."

This shows that RPs were also considering accomplishments and societal impacts that can be accessed through AEC careers.

4.6.3.2 Paired-sample T-test on Survey.

Results from the t-test indicate that there is significant difference between outcome expectations awareness before fAEC-KLM (M = 3.79, SD = 0.35) and after fAEC-KLM (M = 4.00, SD = 0.27); t = -2.83, p = 0.02. The statistical finding suggests that RPs' outcome expectations significantly improved after the intervention.

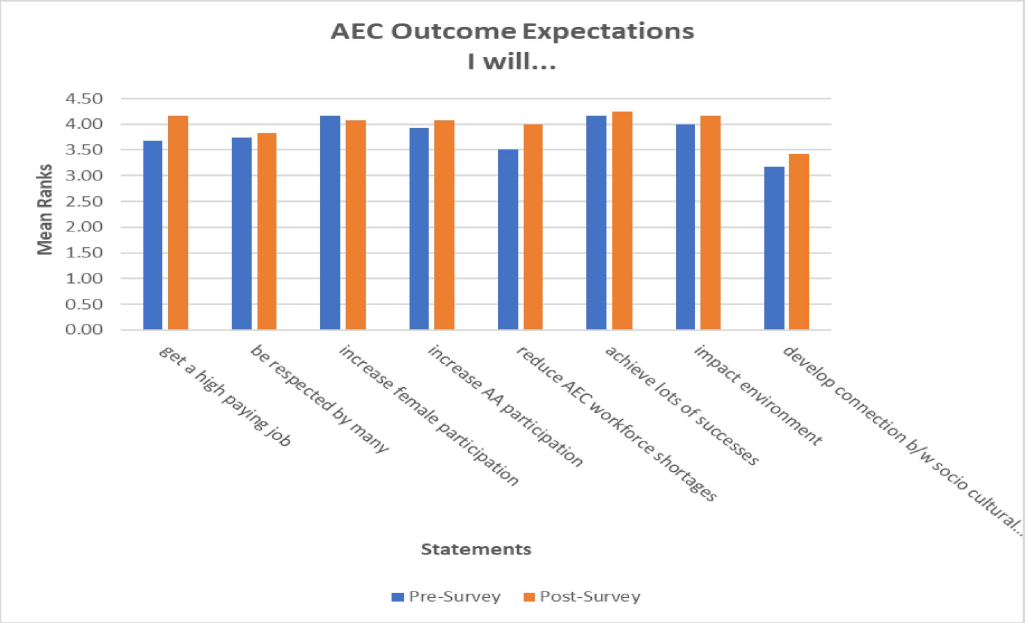


Figure 16. Mean Ranks of AEC Outcome Expectation Statements

Before fAEC-KLM, RPs had limited knowledge about AEC professions and what to expect from these careers. However, after exposure to fAEC-KLM, their outcome expectations became clearer and more positive. This provides strong evidence for the effectiveness of the fAEC-KLM intervention in improving RPs' outcome expectations regarding AEC careers. The significant increase in mean scores indicates that RPs developed clearer and more positive expectations about AEC professions after the intervention. This aligns with Lent's SCCT model (Lent et al., 1994), which emphasizes the importance of outcome expectations in shaping career interests and choices. The improvement in outcome expectations was particularly noteworthy of RPs' initial lack of knowledge about AEC outcome expectations. This suggests that the fAEC-KLM program was effective in providing comprehensive and accurate information about AEC careers, helping RPs form more informed and positive expectations. As Bandura, (1994) noted in his social cognitive theory, outcome expectations play a crucial role in motivating behavior, including career-related decisions. The significant change in outcome expectations also supports the

qualitative findings from the interviews, where RPs expressed gaining new insights into the benefits and nature of AEC careers. This triangulation of qualitative and quantitative data strengthens the overall findings of the study and provides robust evidence that established the effectiveness of the intervention and contributes to the understanding of AEC career interest development in African American middle school girls.

4.6.4 fAEC-KLM Impacts on AEC Career Interests

4.6.4.1 Thematic Analysis of Interview

The fAEC-KLM impacted the AEC career interest of RPs through gain in knowledge, sense of belonging, and self-efficacy as reported for RQ1. However, different categories of interests were observed in this study. RPs were grouped into three AEC career interest categories based on the levels of interests expressed after the fAEC-KLM intervention. These three categories are: (1) Active; (2) Passive; and (3) Null career interest categories.

1. **Active AEC career interest category (N=3):** This category represents RPs who showed high interest in AEC careers. They tended to value creativity as a career-relevant attribute that can be incorporated into their future careers and enjoy playing games that showcase their creativity as expressed by Ann:

   > *"I think I am pretty creative like sometimes I like drawing and stuff... Me wanting to be an interior designer, well, I like playing Roblox. So, in Roblox, you can like build houses and stuff and yeah, you can design the houses, and I know it's fun for me."*

   Nana also expressed her creativity and playing creative games by stating:

   > *"I like decorating things. I like to build. I play a lot of games that require building and decorating. So that kind of interrelates with interior design and just*

construction in general. I'm creative. I just enjoy doing things around that category."

These statements highlight how important creativity means to them and the practical engagement that distributed their creativity. They strongly believe that creativity will be useful in their future careers. RPs in this category also expressed interest in AEC-related careers. Ann and Nana want to be interior designers, while Stephanie wants to be a construction professor in the future. Another characteristic of RPs in this interest category is that they have had previous OST STEM learning in form of summer camps or an AEC family member that basically gave them prior insight into what AEC careers mean noted by Stephanie:

"*I wanna be an engineer. My grandma is an engineer, and she, well, she used to be an engineer. I would like to build stuff to like make life better."*

This validates the importance of role models in career decision making processes as it impacts self-efficacy in pursuing such careers (Gibson, 2004; Quimby & De Santis, 2006). Furthermore, it confirms the importance of multiple engagements in OST programs. RPs also exhibited high math abilities and low social abilities as Ann explained:

"I think first of all, I don't really think I'm that much of a social person but I mean I still have some friends that I would like to talk to and hang out with but I don't hang out with them often and I think that, I think I don't know if I really like math but I think I'm still pretty good at it. So yeah."

RPs in this category also expressed the impact gender has on them wanting to implement aesthetics into their careers as expressed by Ann:

"I think being a girl I think I would just like things to look nice, to make things look pretty and you know attractive. So yeah."

This statement reflects how traditional gender norms can influence self-perception and career interests. The RP associates her identity as a girl with an interest in aesthetics—specifically, in making things "look nice" and "attractive." From responses to the question, "How has your gender and race influenced your top career choices." RPs in this category related intersectionality to their creative self-meanings highlighting how gender identity can subtly shape one's career aspirations and interests, often aligning with broader cultural associations between femininity and aesthetics.

Low social abilities expressed by the RPs in the active interest category shows that social abilities might not be a necessity for activating AEC career interest in this category of African American middle school girls. These RPs also ranked their AEC career interests high in both pre- and post-interviews. They appeared to be more independent, analytical, and creative.

2. **Passive AEC career interest (N=9):** This AEC career interest category captures RPs who exhibited mid (3) to high (5) interest in AEC careers. They ranked AEC as second or third career choice suggesting that they are more committed to non-AEC careers. However, they note that they might still pursue AEC careers if their first non-AEC career choice does not work out as explained by Beverly:

   "Cause like I said, I would really like to do like being like, do medical like be a doctor or something like that. But I would also want to be in the AEC profession industry, because it seems like more interesting. But I would also like to do other career options. So that's why it's not really a 5, because maybe I want to do

something else. But right now, it's really most. I really mostly want to do AEC profession."

These RPs also value teamwork, social interactions, and expressed their analytical and creative abilities are relevant to their future non-AEC career interests as emphasized by Hatti:

"I can work with people like be social and I am smart, and that I could come up with good ideas."

Valuing teamwork has been a critical career interest factor that has been implemented in medical nursing, and environmental studies (Adegbite & Hoole, 2024; Deemer et al., 2022; Hastie & Barclay, 2021). These studies have shown that teamwork helps build career self-efficacy in students. Although RPs did not directly mention having creative abilities, they did mention their ability to come up with good ideas. Most of them also have prior exposure to OST STEM learning through summer camps which caused the initial misconception of the engineering in AEC to mean robotics and coding as explained by Beverly during the pre-interview:

"I did like I like the engineering part because it taught me like it taught us how to use robotics and how to program the real body. and it was really fun to do, and I learned how to do that at the camp... I've done I Yes, I done robotics before, before that camp, but it wasn't just for a female that that one and that the last camp, it taught me a little bit more about robotics."

However, after the fAEC-KLM intervention, she got a better understanding of what AEC means and had this to say:

"My interest increased a lot, because at first, I thought I didn't want like really anything to do with engineers and like building, but the camp kind of changed my mind and now I have more of an interest in doing it than I did before."

RPs in this category also recognized the influence of race and gender on their career aspirations as expressed by Brishae:

"I would say, like growing up because of my gender and my race, I've kind of been pushed to go into certain fields like medical but that's what it mainly affects. I guess it just it's because most women go into that field. But outside of that. finding out about engineering and in journalism that was just out of personal interest and just things that I like to do."

For Brishae, societal expectations have subtly directed her toward certain fields, such as medicine, which are perceived as more common for women. She attributes this to traditional gender norms and expectations for African American women in her community. However, Brishae also emphasizes her personal interests in fields like engineering, which she chose independently of these external influences.

Another statement by Bridget relates her understanding of the importance of her African American and female identities (intersectionality) to success of female African American professionals:

"Because I would be another African American female in a career where it's not a lot, and I'll probably be pretty successful because, because a lot of the African American females that are in the careers are successful. So if I would just like take inspiration from them, I could be successful just like them."

RPs in this category related intersectionality to underrepresentation and a nuanced understanding among participants that, while intersecting identities of race and gender can shape career expectations, personal interests and self-determination can still lead them to explore less traditional paths.

Some commonalities between the active and passive interest categories will be their creative and analytical abilities and prior exposure to OST STEM learning. It can be said that prior exposure to OST STEM learning, creative and analytical abilities reinforce AEC career interests in African American middle school girls.

3. **Null AEC career interest (N=2):** This interest category captures RPs who exhibited no AEC career interest before and after fAEC-KLM intervention. They ranked their AEC interests low (1 or 2) and never mentioned any AEC career as a top future career choice. Instead, they prioritized careers that implement their social abilities. This is expressed in a statement by Loraine:

> *"... it'll probably be social worker, maybe school counselor and I haven't necessarily thought of the third option yet, but those will probably be my top 2…I'll probably try to incorporate my empathy and my critical thinking skills…I don't really think that my gender has influenced my top career choices that much, because the career choices that I choose kind of have, like an equal amount of men and women and the and as for the reason, it's already kind of diverse, so I wouldn't say that it really influenced or affected my career choices."*

As reflected in Loraine's statement, participants in this category perceived no significant influence of intersectionality on their career choices. They believed that their identities as African American females did not impact their career decisions, viewing

these fields as already inclusive and diverse. This suggests that, for some, representation in certain fields creates a sense of acceptance and neutrality, minimizing the perceived effect of gender and racial identity on their career paths.

RPs in this category also expressed their desires to pursue careers such as photography, social worker, and supreme court justice, which align with their empathy, social, and artistic inclinations. They also expressed an aversion to math and possess no math ability whatsoever as explained by Harris:

> *"I don't see myself going into architecture and being like, Yeah, I want to build a bridge, or I want to draw a picture so you can build. I don't know why, but I don't find that very interesting to me, and the main part of architecture that you really need in there is math calculations, and that part, it really brought it down even more for me because I don't like math, I hate it, will never like it."*

RPs also lacked prior exposure to OST STEM learning and do not see themselves associating with AEC careers in the future. A summary of the characteristics of RPs in the three AEC career interest categories are shown in *Table 7*.

Table 7. *Summary of AEC Career Attributes Levels of Career Interest Categories*

Salient Career Interest Attributes	**Active AEC Interest (N=3)**	**Passive AEC Interest (N=9)**	**Null AEC Interest (N=2)**
Math attributes	Yes	Yes	No
Creative attributes	High	Mid	Low - Mid
Analytical attributes	High	High	Low - Mid
Social attributes	Low	Mid	Mid - High
Preference for kinesthetic learning	High	High	Low
Female Identity	High	High	Low
Female and African American Identity	Low	High	Low
Prior Exposure to OST Learning	Yes	Yes (For most)	No
AEC Career Choice	First	Second or third	None
AEC Career Interest Ranking	High - High	Mid - High	Low

4.6.4.2 Paired-sample T-test on Survey:

The pre- and post-surveys were also used to assess the impact of the fAEC-KLM on the AEC career interests of the RPs by asking them to indicate their interests in the listed AEC careers. T-test conducted on the mean ranks of responses shows the increase in AEC career interests of RPs as shown in *Figure 17*.

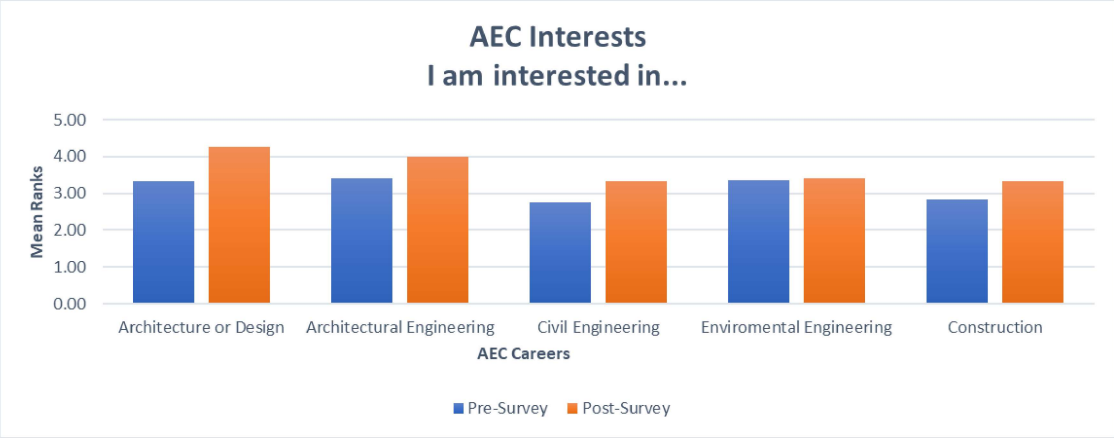


Figure 17. Mean Ranks of AEC Career Interests

Results from the t-test show that there is significant difference in AEC career interests before fAEC-KLM (M = 3.14, SD = 0.32) and after fAEC-KLM (M = 3.67, SD = 0.43); t = -3.84, p = 0.02. This satisfies the major purpose of this study which is to expose African American middle school girls to a femalized kinesthetic learning model to increase their AEC career interests. The significant difference in AEC career interests shows that the fAEC-KLM in parts or as a whole did in fact increase their interests in AEC careers. Interest in Architecture or Design and architectural engineering were higher than others mostly because RPs connected these AEC careers to their love for drawing and creativity. Responses in the interviews expatiate on the decision making of the RPs with respect to AEC learning experiences and interests.

4.6.4.3 Descriptive Analysis of Observation

Results from the observation analysis show the duration in seconds that RPs from each of the three AEC career interest categories (Active, Passive, and Null) in *Table 7* spent on activities encapsulated within the three most effective components (Lecture on AEC, bridge construction project, and peer interactions) of the fAEC-KLM. These results are reported for one RP from each interest category. Therefore, the results are analyzed and reported for Nana with the Active category, Louise for the Passive category, and Harris for the Null category.

a. AEC Lectures

As shown in *Figure 18*, results from the translated videos during AEC lectures show the engagement percentages of RPs for each fAEC-KLM lecture-related activity.

i) *Note-taking*: Nana with active AEC interest displays more discipline in notetaking throughout the lectures as a means to retain information on AEC concepts. Within the one hour analyzed for notetaking, observation records an engagement of 87.2% in notetaking. Louise with passive AEC interest has a slightly lower engagement percentage of 84.1 in notetaking, while Harris with null AEC interest has an engagement percentage of 66.6%.

ii) *Asking Questions:* Louise, with passive AEC interest asked more questions during the AEC lectures with an engagement percentage of 3.2% to obtain clarity on AEC concepts. Nana with active interest came in second with an engagement percentage of 2.6%, while Harris with null interest asked no questions during this lecture and has an engagement percentage of 0%.

iii) *Agreeing to Statements*: Louise with passive interest was more responsive to statements made by the instructor in response to questions asked or emphasized

AEC concepts with an engagement percentage of 2.9%. Nana with active interest had an engagement percentage of 2.2%, while Harris with null interest had an engagement percentage of 0%.

iv) *Peer Interaction:* Harris with null interest had the highest engagement percentage of 14.2% for peer interactions during AEC lectures. She was observed asking peers for clarification and discussing concepts taught but not directing conversations or questions to the instructor. Louise with passive interest had an engagement percentage of 5.8%, and Nana with active interest had an engagement percentage of 3.3%. These RPs were mostly answering questions asked directly to them by their peers.

v) *Distracted:* Harris with null interest had the highest engagement percentage of 19% for being distracted during the AEC lectures, she was either on her phone or engaged in an unrelated activity. Nana was not distracted and Louise had low levels of distraction.

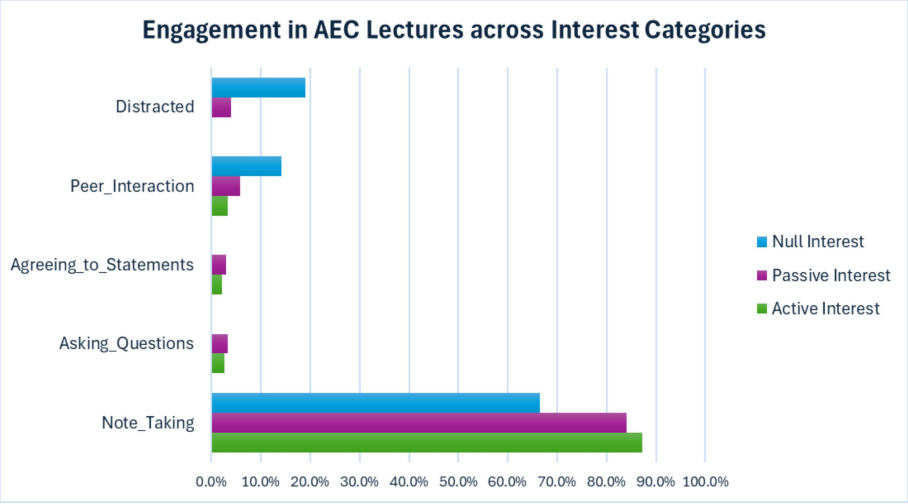


Figure 18. Engagement Percentages for AEC Lectures across Interest Categories

b. Bridge Construction Project

Results from translated videos on the bridge construction project show the engagement percentages of the same three RPs for each bridge construction-related activity. This is summarized in *Figure 19*.

i) Kinesthetic activity: Nana with active interest had the highest engagement percentage of 58% for kinesthetic activity, while Louise with passive interest had an engagement percentage of 56.8%. Harris with null interest had the lowest engagement percentage of 36.1%.

ii) Design: Harris with null interest had the lowest engagement percentage of 2.8%, while Louise with passive interest had an engagement percentage of 8.3%. Nana with active interest had the highest engagement percentage of 8.4%.

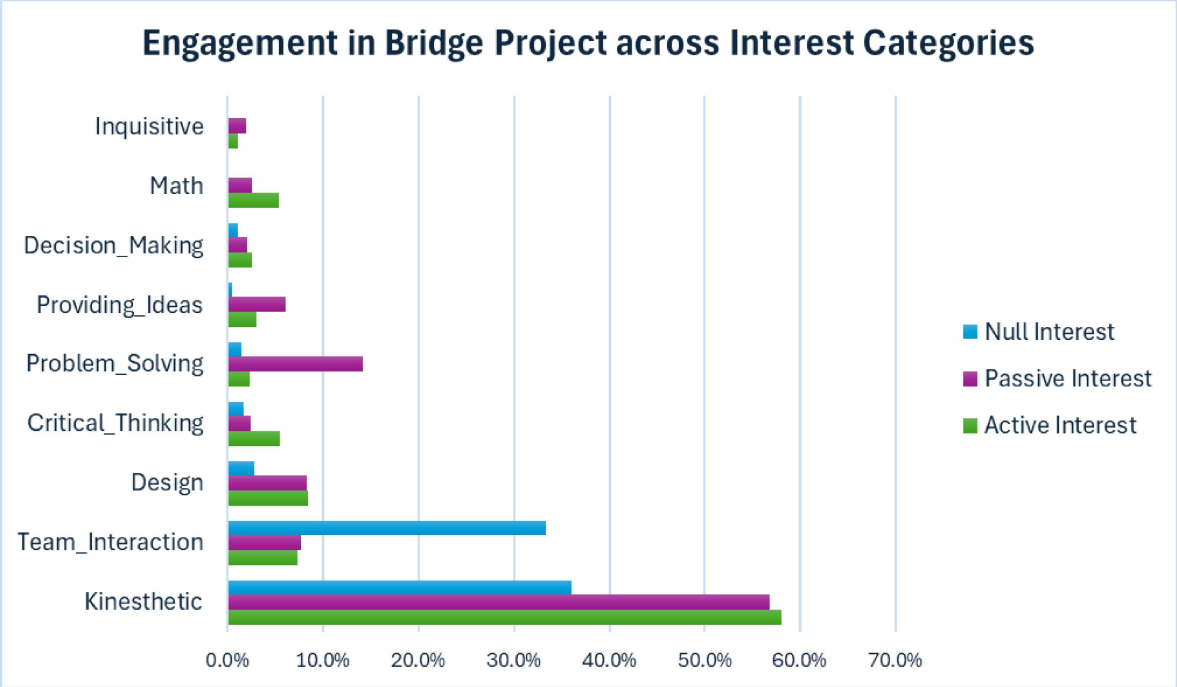


Figure 19. Engagement Percentages for Bridge Project Across Interest Categories

iii) Math: Nana with active interest had the highest engagement percentage of 5.4%, Louise with passive interest had an engagement percentage of 2.6%, and Harris with null interest had no engagement with an engagement percentage of 0%.

iv) Critical thinking: Harris with null interest had the lowest engagement percentage of 1.7%, Louise with passive interest had an engagement percentage of 2.4%, and Nana with active interest had the highest engagement percentage of 5.4%.

v) Problem-solving: Louise with passive interest had the highest engagement percentage of 14.2%, Nana with active interest had an engagement percentage of 2.3%, and Harris with null interest had the lowest engagement percentage of 1.4%.

vi) Inquisitive: Louise with passive interest had an engagement percentage of 1.9%, Nana with active interest had an engagement percentage of 1.1%, and Harris with null interest had no engagement with an engagement percentage of 0%.

vii) Decision making: Nana with active interest had an engagement percentage of 2.6%, Louise with passive interest had an engagement percentage of 2%, and Harris with null interest had an engagement percentage of 1.1%.

viii) Providing Ideas: Louise with passive interest had an engagement percentage of 6.1%, Nana with active interest had an engagement percentage of 3.0%, and Harris with null interest had an engagement percentage of 0.4%.

ix) Team interaction: Harris with null interest had the highest engagement percentage of 33.4%, Louise with passive interest had an engagement percentage of 7.7%, and Nana with active interest had the lowest engagement percentage of 7.3%.

This validates interview findings that showed RPs in the null interest categories had the strongest career-relevant social skills.

c. Peer Interactions

Results from translated videos on peer interactions show the engagement percentages of RPs for each peer interaction-related activity.

i) *Conversation with peers:* Louise with passive interest had an engagement percentage of 13.8% for having conversations with other girls. She described feeling destressed when discussing personal and school experiences with a select group of RPs. Nana with active interest had an engagement percentage of 13.1%, while Harris with null interest has an engagement percentage of 12.1%.

ii) *Conversation with teammates:* Harris with null interest had the highest engagement percentage of 43.9%. She created a stronger bond with her teammate but not necessarily other girls within the camp. With an engagement of 25%, Louise with passive interest was just slightly more engaged in conversation with teammates than Nana with passive interest at 24% engagement.

iii) *Listening:* Harris with null interest had more conversations with her teammate and this resulted in the highest listening engagement percentage of 44%. Louise with passive interest had an engagement of 37.9%, while Nana with active interest had the lowest listening engagement percentage of 35.5%.

iv) *By self (Isolated):* Nana with active interest had the highest engagement percentage of 21.4%. She occasionally kept to herself and did not relate to anyone during the fAEC-KLM. Louise with passive interest had a 15.8% engagement percentage, while Harris with null interest had no engagement with an

engagement percentage of 0%. This is because the Harris with the null interest had great interactive skills and was never alone.

v) *Uninteractive:* Louise with passive interest had the largest engagement percentage (7.3%) for being uninteractive. Nana with active interest had 5.1%, while Harris with null interest had 0%.

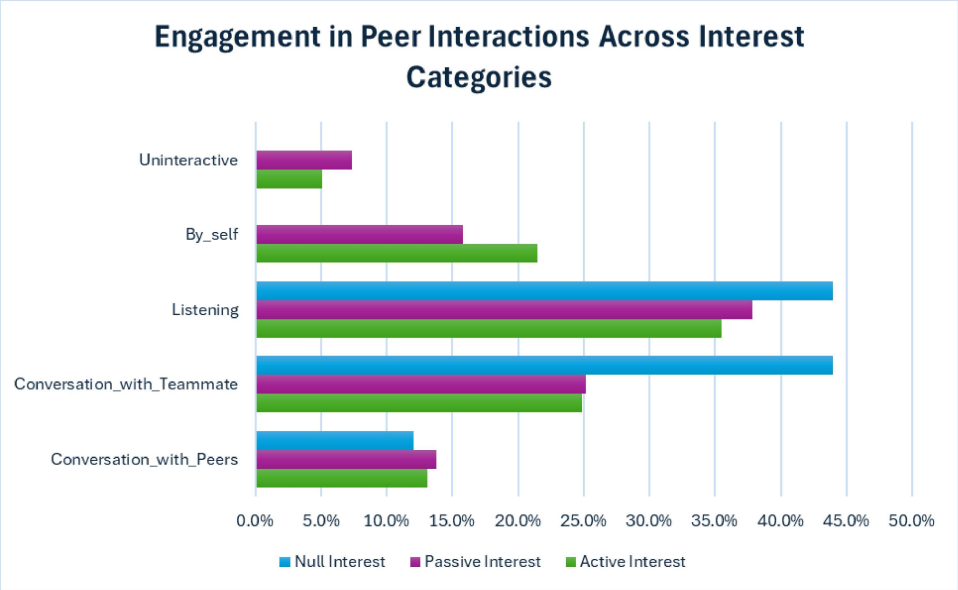


Figure 20. Engagement Percentages of Peer Interactions Across Interest Categories

A description of all activities within the top effective components of the fAEC-KLM are detailed in Appendix B.2 providing meanings to the activities described in the results above.

The fAEC-KLM intervention increases understanding how African American middle school girls across different AEC career interest categories engage with OST AEC learning experiences. The observation analysis offers nuanced insights into how RPs with active, passive, and null AEC interest categories developed different levels of AEC career interests as they interacted with key components of the fAEC-KLM: AEC lectures, bridge construction project, and peer interactions.

Results highlight that RPs with active and passive interests were more engaged in note-taking, kinesthetic, and problem-solving tasks. In contrast, RPs with null interest showed higher involvement in social aspects, such as peer interactions and teamwork, even though they remained less engaged with structured AEC learning activities. This finding suggests that girls with lower AEC career interest might still benefit from a program that provides significant opportunities for interpersonal connections while engaging in AEC learning. Interestingly, RPs with passive interest often exhibited high engagement in specific activities, such as asking questions and providing ideas, suggesting that this group may respond well to structured AEC interventions that encourage curiosity and collaboration. Conversely, the lack of engagement in lectures and AEC-related tasks among RPs with null interest underscores the importance of individualized strategies to activate and sustain interest across diverse learning preferences.

In alignment with interview results, observation findings suggest that RPs in active career interest category tended to have career-relevant creative abilities, passive have analytical, and null have social attributes. Notably awareness of underrepresentation activated a desire to contribute to solving this problem. This was observed in girls who had strong female and black identities (intersectionality).

The fAEC-KLM shows promise in its ability to cater to different engagement styles and potentially foster interest in AEC careers, even among initially disinterested RPs. However, the data also highlights areas for refinement, particularly in lecture delivery and in encouraging more uniform engagement in higher-order thinking skills across all interest categories. Future iterations of the program could benefit from:

1. Debunking misconceptions.

2. Enhancing interactive elements in lecture components to reduce distraction and increase engagement for all interest categories.
3. Structured peer learning opportunities that capitalize on the high engagement in team interactions, especially for girls in null interest categories.
4. Tailoring approaches to encourage critical thinking and problem-solving across all interest categories.
5. Highlighting African American and female intersectionality benefits.
6. Using longitudinal studies to track how these varied engagement patterns translate into long-term interest and pursuit of AEC careers.
7. Implementing well-paced programs for efficient completion to facilitate gaining a sense of accomplishment which contributes to interest.
8. Developing individualized teaching plans especially for girls within null interest category.
9. Incorporating more female African American role-model interactions.
10. Teaching coping strategies for thriving in male-dominated spaces.
11. Including field trips to summer camps.
12. Creating models with intervention projects that have higher components of creativity, analytical, and socialization.
13. Providing longer camp durations and repeated interventions for middle school girls, possibly all the way through high school.
14. Increasing awareness of female and African American representation.

This nuanced understanding of engagement patterns provides a solid foundation for refining the fAEC-KLM, potentially increasing its effectiveness in fostering interest in AEC

careers among diverse groups of students. Images of constructed bridges by RPs is seen in *Appendix E*.

CHAPTER 5

Conclusion

5.1 Summary

This study aimed to increase understanding of how the salient identities of African American middle school girls interact with learning experiences within a developed femalized AEC kinesthetic learning model to impact AEC career interests. This empirical work is crucial because the severe AEC workforce shortages limit the capacity of this industry to meet the increasing demands for construction work. The need for talented personnel and diversified innovations can partly be met by increasing the participation of African American women in this workforce (Heydari et al., 2024; McKissak, 2023; Choi et al., 2018). Therefore, creative interventions such as the fAEC-KLM intervention are needed to eliminate existing barriers to AEC career interests in African American girls. Considering that limited empirical work and literature addresses AEC career interests in this demographic, findings from this study fill gaps in career development literature to increase understanding and support of African American middle school girls to strengthen their transitions into undergraduate AEC programs and into the AEC workforce.

The findings from this research study align with prior career development and intersectionality frameworks established by Robert W. Lent, Albert Bandura, and Kimberle Crenshaw. They highlight the importance of pre-dispositions, learning experiences, self-efficacy, outcome expectations, and intersectionality in AEC career interest development in African American middle school girls. Furthermore, findings are in alignment with existing literature on how components of all-female and African American AEC-infused OST interventions with kinesthetic learning engagements contribute to AEC career knowledge, understanding, self-

efficacy, and interest development in African American middle-school girls (Ofori-Boadu et al., 2019; Ofori-Boadu, 2018; Luster-Teasley et al., 2016). Its uniqueness lies in its adoption of the intersectionality lens which allowing its findings to fill a critical gap in career development literature by highlighting how gender and culturally responsive kinesthetic learning interventions foster gains in AEC knowledge, self-efficacy, outcome expectations, and career interests in African American middle school girls. Considering that existing literature on career development tend to have small proportions of African American middle school girls, findings provided nuanced insights that are more fully applicable to increasing AEC career interests in this demographic.

Findings indicate that the fAEC-KLM is an effective tool for assessing how learning experiences influence AEC career-related knowledge, self-efficacy, outcome expectations, and interests in African American middle school girls. Inductive thematic analysis resulted in the emergence of the central theme, *fAEC-KLM Increases AEC Career Interests in African American Middle School Girls*, which explains effective fAEC-KLM components, salient identities, learning interactions, and categories of AEC career interests associated with engagement in fAEC-KLM. Three AEC career interest categories (active, passive, and null) are utilized to explain how varying fAEC-KLM interactions contribute to three different levels of AEC career interests in African American middle-school girls. While girls in active interest category tended to associate their AEC career interests with their salient career-relevant creative and female attributes, girls in passive interest category tended to associate interests with their salient career-relevant analytical, as well as female and African American attributes. With salient social attributes being salient and career-relevant, girls in null interest category found minimal

opportunities for socialization and communications within the fAEC-KLM model and so experienced lower connections with AEC careers and no development of AEC career interests.

The emphasis on the need for knowledge through lectures, mastery experiences with kinesthetic learning, and a sense of belonging through vicarious gender and racial career-related learning experiences in educational settings make these insights valuable. They inform research and practice to improve the representation of African American women and reduce workforce shortages in masculine and male-dominated AEC careers (Boone, 2016; Gonzales, 2014). Positive learning experiences within the fAEC-KLM interacted with salient identities of RPs to impact AEC knowledge (I know), self-efficacy (I can), sense of belonging (I feel), and interests (I want). This shows that creative, analytical, social identities, as well as female and African American AEC identities interacted with the different components of the fAEC-KLM to influence AEC career interest categories. Interestingly, more girls associated their AEC career interest development to the female over their African American identity. African American middle school girls relate better with careers that hones or highlights self-attributes that they consider unique to themselves as evidenced by the sub-themes.

Also, regardless of methods (interviews, surveys, tests, and observation), the same fAEC-KLM components are reported to impact AEC career knowledge, self-efficacy, outcome expectations, and interests. Across all methods, lectures, kinesthetic activities, and peer interactions had the most impact on the AEC knowledge, self-efficacy, outcome expectations, and interests of RPs. This simply means that to increase AEC career-related knowledge, self-efficacy, outcome expectations, and interests of African American middle school girls, it is paramount that activities that impact “I know,” “I can,” and “I feel” self-meanings are implemented.

Effective components of the fAEC-KLM impacted AEC career interests in African American middle school girls through:

1. Gain in Knowledge: The model significantly enhanced RPs' understanding of AEC concepts, as evidenced by the improvements in their ability to articulate technical terms and processes. Through lectures and hands-on activities, like the bridge construction project, RPs transitioned from limited pre-intervention knowledge to a more comprehensive understanding of the field. This increase in knowledge highlights the effectiveness of targeted OST programs in addressing gaps left by traditional school curricula and fostering an early interest in AEC careers.

2. Gain in Self-efficacy: RPs demonstrated a notable increase in self-efficacy, with many expressing confidences in their problem-solving, mathematical, and creative abilities as relevant to AEC careers. The model's emphasis on informative lectures, hands-on learning, and exposure to African American female AEC professionals enabled RPs to see themselves as capable of succeeding in these traditionally masculine and male-dominated fields. The alignment of self-attributes with career-related activities through meaningful experiences proved critical in reinforcing RPs' belief in their ability to pursue AEC careers.

3. Gain in Sense of Belonging: Participants with strong female and African American identities found deeper resonance with the historical achievements of African American women in AEC fields, positioning themselves as both problem solvers and advocates for greater representation in AEC careers. By connecting with their female and African American peers and role models, they were empowered to envision their own potential impact within the AEC space, strengthening their sense of identity and purpose. The

fAEC-KLM fostered a powerful sense of belonging by creating an environment that validated and celebrated participants' identities as African American girls. This inclusive approach embraced Crenshaw's intersectionality, recognizing the unique ways race and gender intersect to shape their experiences in underrepresented fields like AEC. Through peer interactions, mentoring by African American female AEC professionals, and collaborative projects, participants felt welcomed and supported, developing a strong, positive sense of African American identity within the AEC space. This connection to role models and historical figures, combined with a sense of belonging, is critical to sustaining their long-term interest and engagement in AEC careers. It provides them with the social and emotional foundation to navigate and overcome the compound challenges they may face due to their intersecting identities. Furthermore, it validates the importance of counter spaces to support AEC career interest development in this demographic.

The findings in the study show that fAEC-KLM components strongly validate all four of Bandura's key elements of self-efficacy: mastery experiences, vicarious experiences, physiological feedback, and verbal persuasions. However, all physiological feedback elements in the fAEC-KLM were ranked bottom suggesting that physiological feedback might not be as important to African American middle school girls when looking at the model interaction with AEC career interests as it is to other demographics.

5.2 Recommendations for future AEC-infused OST interventions for African American girls

Across all RPs, certain activities and experiences emerged as crucial and provided insight for developing effective AEC-infused OST interventions:

1. Lectures: While other studies with other populations suggest that lectures in OST programs may not be as effective, African American middle school girls tended to associate their career interest with knowledge gained from lectures on AEC content, outcome expectations, and women and African American underrepresentation in AEC careers (Bajak, 2014).

2. Early Exposure and Role Models: Early exposure to AEC careers and the influence of family members or mentors in the field significantly enhance career interest and aspirations.

3. Kinesthetic Learning: Hands on activities, such as bridge design and construction, were repeatedly highlighted as effective in increasing AEC career interest, particularly girls in the active and passive AEC Career Interest Categories.

4. Intersectionality-relevant Approaches: Addressing the importance of the intersection of gender, race, and career development provides insight into the benefits that African American middle school girls can obtain from gender and culturally responsive AEC-infused OST learning environments and counter spaces as observed in girls in the active and passive AEC Career Interest Categories.

5. Addressing Misconceptions: Clarifying the scope and nature of AEC careers can transform initial misconceptions into genuine interest, as observed in girls in the passive AEC Career Interest Category.

6. Individualized and Diverse Learning Experiences: Providing individualized and diverse learning experiences, to include math support and increased opportunities for public

speaking, can cater to different interests and learning styles such as was observed in girls in the null AEC career interest categories.

7. OST Project Structure: Strategically designing projects that can be successfully completed within the timeframe of an OST program is crucial. Ensuring project completion within the allotted time positively impacts the self-efficacy of research participants and strengthens their confidence and motivation due to their sense of accomplishment.

This study highlights how salient identities had positive interactions within the fAEC-KLM through self-meanings associated with collaboration, problem-solving, and intersectionality. While some aspects of the fAEC-KLM demonstrated strong impacts, others indicate areas where the model could be further refined to better align with RPs' identities, learning preferences, as well as gender and cultural values. These findings demonstrate that while the fAEC-KLM intervention made meaningful strides in nurturing self-meanings aligned with AEC career interests, there are areas for improvement. Future OST programs can refine their approach by embedding gender and culturally relevant content and diverse learning experiences that resonate with RPs' identities and aspirations, ensuring that African American girls see themselves as capable contributors in AEC fields.

5.3 Implications

Early exposure to AEC careers through AEC-infused OST interventions present opportunities for African American middle school girls to develop interests and pursue AEC careers (Ofori-Boadu, 2018; Roberts et al., 2018; Tai et al., 2006). This is proven by the interest levels associated with the active and passive AEC career interest categories. The value of incorporating both formal and informal lectures, kinesthetic and experiential activities,

interactional, and female and African American approaches to stimulate career interests in underrepresented groups is illustrated in this study. The combination of content-focused learning with practical application aligns with established theories of experiential learning and social constructivism, emphasizing the importance of active engagement and collaboration. The fAEC-KLM intervention serves as a model for addressing the intersectional (race and gender) challenges faced by African American girls in developing career interests in AEC fields, providing them with the knowledge, tools, and confidence needed to explore AEC careers.

For African American girls, findings in this study highlight the need for them to know and understand their own salient career-relevant attributes by participating in more OST interventions that increase their awareness and capacity to make career-related decisions, particularly towards careers with low female and African American participation.

For educators and practitioners, the findings in this study highlight the critical role that OST programs play in fostering AEC career interest among African American middle school girls. OST programs should integrate creativity, cognitive skill-building, and social interaction into their design, offering hands-on activities that make learning tangible, engaging, and directly connected to real-world applications (National Research Council et al., 2012). Such experiential learning enhances students' understanding, builds confidence, and aligns their strengths with AEC career pathways. Additionally, addressing misconceptions about AEC careers early on within OST settings ensures RPs comprehensively understand the field's diversity and opportunities. Educators and practitioners should collaborate in the development of AEC-infused AEC interventions. Particularly, HBCUs should increase their commitment to supporting career identity development processes in African American middle-school girls. Long-term interest in girls can be further cultivated through mentorship programs and partnerships with female and

African American AEC professionals, providing role models and practical guidance (Fouad & Santana, 2017). Sustained exposure through OST programs can reinforce RPs' self-efficacy, broaden their career outlook, and help them develop essential skills needed for future success in AEC fields.

For policymakers, they should prioritize the development of educational and career development policies that facilitate early and equitable access to STEM learning opportunities, recognizing the significant impact of OST learning experiences on career interests. Investing in policies, programs, and other interventions that offer diverse and sustained STEM engagement, such as summer camps and mentorship initiatives, is crucial (Holdren et al., 2010). Collaboration between educational institutions, industry partners, and community organizations can enhance the effectiveness of these initiatives, ensuring a cohesive approach to STEM education. Additionally, addressing gender and cultural disparities in STEM career pathways should be a focal point, ensuring all students can explore and pursue AEC careers.

5.4 Future Research Directions

The findings from this study present several implications for future research. Larger research population sizes should be employed to validate findings and increase understanding of the nuanced internal and external factors that influence AEC career interests in African American girls. Furthermore, control groups should be employed. Longitudinal studies that track changes in career interest over time would be valuable, providing insight into the long-term impacts of early AEC-infused OST interventions and AEC career exposure. Additionally, exploring the role of gender and cultural background in shaping career interests can enhance understanding of diverse experiences and needs. Investigating how girls with salient career-relevant social attributes as observed in girls in the null Career Interest Category can develop

AEC career interests through specific OST interventions will provide actionable insights for program development. The persistence of low self-efficacy in some RPs underscores the need for continued research and refinement of such programs. While the fAEC-KLM enhanced RPs' awareness, some lingering biases about gender-specific roles in AEC careers persisted, suggesting that more profound cultural shifts are necessary to challenge long-held stereotypes. Future interventions might benefit from more personalized approaches that consider individual interests and learning styles.

5.5 Assumptions, Challenges and Limitations of Study

An assumption of this study is that research participants understand questions and provide accurate and honest responses during surveys, interviews, and tests. However, observation methods allowed the observation of research participants in more naturalistic settings within the OST program.

A primary challenge encountered in this study was recruiting a large sample of African American middle school girls to participate in the study. Although recruitment flyers were distributed to over 50 middle schools within Guilford County, only 16 African American middle school girls filled out the application form. This validates the problem of this study in that this demographic has low AEC career interests. Nevertheless, for future studies, a pre-intervention seminar can be organized in middle schools to inform African American middle school girls about the importance of the model and how it impacts their AEC career interest development before providing the application forms. Furthermore, short videos with important aspects of AEC careers can be shared with potential participants. This can help improve the participation of this demographic in the fAEC-KLM intervention. This study also has some limitations that can be rectified or improved in future studies.

1. Small Sample Size: the limited number of RPs restricts the generalizability of the findings to other populations. Although the study provides valuable insights into the experiences of African American middle school girls, larger sample sizes would be necessary to strengthen the validity and applicability of the results across diverse contexts.

2. Short Intervention Duration: The five-day summer camp provided only a brief exposure to AEC careers, which may limit the depth and retention of knowledge acquired by RPs. A longer intervention or follow-up sessions would allow for a more robust evaluation of sustained impact and career interest development.

3. Focus on Top Components Only in Video Analysis: The study only analyzed activities within the three most effective fAEC-KLM components. This selective analysis may overlook other meaningful activities or behaviors that could provide additional insights into RPs' engagement and learning.

4. Limited Long-Term Impact Assessment: The study did not include follow-up assessments to determine if the RPs' interest in AEC persisted beyond the summer camp. Understanding the intervention's long-term influence would require longitudinal tracking of the RPs' educational and career trajectories.

5. Persistent Stereotypes: Despite gains in AEC knowledge, some RPs continued to express stereotypical beliefs about the women's roles in AEC, such as assuming women are less inclined towards hands-on construction work. This indicates that short-term interventions alone may not fully dismantle deeply rooted cultural biases.

6. Sample Representativeness: The RPs were drawn from a specific location and population of African American middle school girls. While this focus aligns with the study's goals, the findings may not reflect the experiences or challenges of other underrepresented groups in STEM, such as African American girls in other geographical locations, boys, or students from other racial or socioeconomic backgrounds.

5.6 Conclusion

It is essential to build upon the initial success of the fAEC-KLM model. Therefore future research and program development should consider the following recommendations to support interest and persistence of African American girls into male-dominated fields such as the AEC workforce:

1. *Larger Sample Size*: Expanding the study to include a larger sample size will provide a more comprehensive understanding of how diverse backgrounds and experiences impact AEC career interests and engagement.
2. *Enhanced Interactive Lecture Elements*: Integrating more interactive components in lectures can help reduce distractions and maintain engagement across all interest levels, ensuring each participant remains actively involved.
3. *Structured Peer Learning Opportunities*: Designing structured peer learning opportunities that leverage high engagement in team interactions will be particularly valuable for participants initially expressing little interest in AEC. These activities can stimulate interest through collaborative learning and shared goals.
4. *Tailored Approaches for Critical Thinking and Problem-Solving*: Developing tailored strategies to foster critical thinking and problem-solving skills across all interest

categories can empower participants to view themselves as capable problem solvers, aligning with the skills needed in AEC fields.

5. *Longitudinal Studies for Tracking Engagement*: Conducting longitudinal studies is crucial for understanding how engagement in OST programs translates into sustained interest and eventual pursuit of AEC careers. Tracking participants over time will reveal the long-term impact of these programs and help refine future interventions.
6. *Culturally Relevant Content and Diverse Learning Experiences*: Future OST programs should incorporate culturally relevant content and diverse learning experiences that resonate with the identities and aspirations of African American girls. This approach helps participants see themselves as valued contributors to the AEC industry, strengthening their confidence and interest.
7. *Repeated OST Interventions*: Repeated OST interventions at different developmental stages, extending through high school, can help reinforce and nurture AEC career interests over time. Consistent exposure to AEC-related content, mentorship, and skill-building activities will strengthen career identity and resilience, increasing the likelihood of sustained interest in AEC pathways.

The fAEC-KLM intervention provides a promising model for increasing diversity in AEC fields by targeting middle-school phase as a crucial career interest developmental stage for African American girls. To increase AEC career interests in African American middle school girls, it is essential to first attract these girls with an evidence-informed OST model such as the fAEC-KLM that incorporates career development literature and strategies to cater to the different learning styles of girls. These strategies could be in the form of career-related lectures, kinesthetic learning, peer interactions, interactions with

gender, culture, and career relevant role models as these proved to be most effective in increasing the AEC career interests of RPs in this study. In conclusion, this study addresses a critical gap in the literature on career development processes in African American middle school girls by offering nuanced insights into the drivers and retarders of their interests in architecture, engineering, and construction (AEC) careers. Existing research has largely overlooked the intersection of race, gender, and career interest formation during early adolescence, particularly in fields like AEC, which have traditionally low female and African American participation. The findings of the fAEC-KLM intervention shed light on how targeted gender and culturally responsive educational programs can effectively foster interest and self-efficacy among this demographic, laying the groundwork for more equitable representation in the AEC workforce.

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APPENDIX

Appendix A: Pre-intervention tools

Appendix A0: IRB Approval

Full Board Approval (Initial)
Date: 20-Jan-2023
To: Fash, Mercy F
Applied Science and Technology (38510)
From: Institutional Review Board
Approval Date: 20-Jan-2023
Expiration Date of Approval: 19-Jan-2024
RE: Notice of IRB Approval by Full Board Review
Submission Type: Initial
Expedited Category:
Study#: HS22-0142
Study Title: Development of a Femalized Kinesthetic Learning Model to
Increase Architecture, Engineering, and Construction (AEC)
Career Interests in African American Middle School Girls
Sponsor:
This submission has been approved by the above IRB for the period indicated.
None. Revisions meet reviewers expectations.
Investigator's Responsibilities:
Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's
responsibility to submit for renewal and obtain approval before the expiration date. You may not continue
any research activity beyond the expiration date without IRB approval. Failure to receive approval for
continuation before the expiration date will result in automatic termination of the approval for this study on
the expiration date.
When applicable, enclosed are stamped copies of approved consent documents and other recruitment
materials. You must copy the stamped consent forms for use with subjects unless you have approval to do
otherwise.
You are required to obtain IRB approval for any changes to any aspect of this study before they can be
implemented (use the modification form). Should any adverse event or unanticipated problem involving
risks to subjects or others occur it must be reported immediately to the IRB using the adverse event form at

the same web site. **If you are conducting research in a location other than North Carolina A&T State University, such as an agency, organization, or school, you must provide written approval from an authorized representative (for example, the superintendent's office for research conducted in a public school) prior to conducting your research.**

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40CFR 26 (EPA), where applicable.

Appendix A.1: Recruitment flyer

RESEARCH PARTICIPATION:
Recruiting Creative African American Middle-School Girls with STEM and Art Interests
We need participants for a research study:
"Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls"

Description of Project: Research is being conducted to assess the impact of a femalized Architecture Engineering and Construction Kinesthetic Learning Model on AEC career interest development in African American Middle School girls. Participation will involve 7 hours for 5 Saturdays at North Carolina Agricultural and Technical State University. Participants will take tests, surveys, and participate in zoom interviews. Also, they will be observed the entire period of this program.
Duration: 5 Saturdays – 1st, 8th, 15th, 22nd, 29th October 2022
To participate: You must be an African American currently enrolled in any middle school in Guilford County, NC.
Participants will receive $100 incentives only after 100% participation.
To participate, apply using the barcode below:

https://forms.gle/bYFnV9oBpEqLzRjUA
APPLY NOW!!!
To learn more, contact the principal investigator of the study, Mercy Fash, at 336 493-1582 or mffash@aggies.ncat.edu
This research is conducted under the direction of Dr. Andrea Ofori-Boadu, Associate Professor, Built Environment, and has been reviewed and approved by the N.C. A&T Institutional Review Board.

Appendix A.2: Application/Recruitment form

Application Form for fAEC-KLM
This is an application form to participate in a research study on the development of a femalized kinesthetic learning model to increase architecture, engineering, and construction career interests in African American Middle school girls. Your participation in this research is greatly appreciated.

* Required

1. First Name *

2. Last Name *

3. Age *
Mark only one oval.
- 11 years old
- 12 years old
- 13 years old
- 14 years old
- 15 years old

4. Are you a female? *
Mark only one oval.
- Yes
- No

5. What grade are you in? * *Mark only one oval.*
- Grade 6
- Grade 7
- Grade 8
- Grade 9 Other:

6. Phone number

7. Email address *

8. Parent/Guardian's contact number *

9. Parent/Guardian's email *

10. What is the name of your middle school? *

11. Is your middle school located in Guilford County? * *Mark only one oval.*
- Yes
- No

12. Disability status *
Mark only one oval.

Yes, ◯ I have a disability
No, I ◯ do not have a disability

13. If yes to the question above, what is your disability?

14. List your five top favorite subjects. *

15. List five options of careers you want to pursue in the future. *

16. For the following dates of the study, please select the best option in response to * your availability.

Mark only one oval per row.

	Yes	No
October 1st	◯	◯
October 8th	◯	◯
October 15th	◯	◯
October 22nd	◯	◯
October 29th	◯	◯

17. Describe yourself (indicate your interests, hobbies, skills, extracurricular activities, * etc.)

18. Give reasons why you want to participate in this study. *

Appendix A.3: Participant Consent Form

Study Title: Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls.
Principal Investigator: Mercy Fash
Faculty Advisor: Dr. Andrea Ofori-Boadu

Hello. I am Ms. Mercy Fash a graduate student in the Applied Science and Technology PhD program with the College of Science and Technology at North Carolina A & T State University. I am the PI for this research which is a partial fulfillment of the requirements for my degree of Doctor of Philosophy in Applied Science and Technology.

The purpose of this study is to understand how a femalized Architecture, Engineering, and Construction Kinesthetic Learning Model (fAEC-KLM) interacts with and increases the AEC career learning experiences, knowledge, self-efficacy, outcome expectations, and interests of African American middle school girls.

You have been asked to participate because you are currently an African American middle school girl enrolled in any middle school in Guilford County, North Carolina.
If you decide to participate in this study, you will first complete a one hour zoom interview to measure the impact your learning experiences has on your career related knowledge, self-efficacy, outcome expectations and interests. This interview will be recorded, recordings will be kept in a password protected computer. The recordings once transcribed will be deleted within one year.
After which, you will complete a 10-minute survey that asks general questions about you and requires you to rank your AEC learning experiences, knowledge, self-efficacy, outcome expectations, and interests. This will be completed before interacting with the fAEC-KLM.
Next, you will complete an AEC pre-test to measure your current knowledge on AEC professions, terminologies, and bridge construction.
The next phase exposes you to the fAEC-KLM which will take place in the span of five (5) Saturdays (TBD) during which you will receive a short lecture on what AEC entails, how to be an AEC professional, and bridge construction after which you will be required to work on an AEC-related project of bridge construction. Please note that all interactions withing the fAEC-KLM will be recorded via video recording. This is to ensure that all interactions are documented for analysis in finding salient identity types of participants.
The final phase of this study entails you completing a 10-minute post-survey and a 10-minute post-test to measure the impacts the fAEC-KLM has on your AEC career-related learning experiences, knowledge, self-efficacy, outcome expectations, and interests. Both will be completed on the last day of the model interaction. Within two weeks of model interaction completion, you will be required to participate in a one-hour zoom interview to get your perception and rankings of the effectiveness of this learning model. All collected data will be destroyed two years after this study. Reports of study findings will not include any identifying information.

Risks
We do not anticipate any risks from your participation in this research.
Compensation
You will receive an incentive of $100 after full participation in this study. Please note that this incentive can only be received when you have 100% participation in this study.

Benefits.
There are no direct benefits to participants in this research. We hope to learn more about the impact this study has, to inform the development of curriculums/programs.

Confidentiality
All information collected in this study will be kept completely confidential to the extent permitted by law. At no time will your actual identity be revealed. You will be assigned a random numerical code. The key linking the code to your name will be kept in a secure location and no one else will have access to it. The code key will be destroyed at the end of the research study. Also, the data will be stored on a password protected computer. Your name or any information that would identify you will not be used in publications or presentations.

Participation/Withdrawal
You do not have to be in this study if you don't want to. No one will be upset. If you want to be in the study now but change your mind later, that's okay. You can stop at any time. When I tell other people about my study, I will not use your name, and no one will know who I'm talking about.

Contact
If you have any questions or concerns about this research, please contact Ms. Mercy Fash by email at mffash@aggies.ncat.edu.

If you would you like to be in my study, please write and sign your name on the lines below.

Student's Name: _____

Student's Signature: _____

Appendix A.4: Parental Permission Form

Study Title: Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls.
Principal Investigator: Mercy Fash
Faculty Advisor: Dr. Andrea Ofori-Boadu

Dear Parent,

You are being asked to allow your child to participate in a research study conducted by Ms. Mercy Fash a graduate student in the Applied Science and Technology PhD program with the College of Science and Technology at North Carolina A & T State University. Before you give your permission for your child to participate, it is important that you read the following information and ask as many questions as necessary to be sure you understand what your child will be asked to do.

Purpose of the Study:
The purpose of this study is to understand the impact the femalized Architecture, Engineering, and Construction Kinesthetic Learning Model (fAEC-KLM) has on the AEC career-related learning experiences, knowledge, self-efficacy, outcome expectations and interests of African American middle school girls.

What Your Child Will Do:

- If you agree to allow your child to participate, she will be asked to first participate in a one-hour zoom interview to get a perspective on their current career-related learning experiences, knowledge, self-efficacy, outcome expectations, and interests. Next, she will complete a pre-survey and a pre-test that asks general questions about her and her knowledge of AEC professions, terminologies, and bridge construction, this will be completed on the first day of interaction with this learning model. The next phase exposes her to the fAEC-KLM which will take place in the span of 5 Saturdays (TBD) during which she will receive a short lecture on what AEC entails and how to be an AEC professional, and how to design and construct a bridge. After which she will be required to design and construct a bridge based on what has been learnt from the lectures. The final phase of this study entails your child completing a post-survey and a post-test and post-interview which will help give us a better understanding on the impacts the fAEC-KLM has on their learning experiences and how these experiences interact with their AEC career-related knowledge, self-efficacy, outcome expectations, and interests. Please note that during the interview processes and interactions with the fAEC-KLM, your child's activities will be recorded with a video recorder and the recordings will be used for further data analysis. While taking the survey or participating in the interviews, your child can skip any question that makes her uncomfortable and can stop the interview/survey at any time.

Time Required:

Each survey and test will take about twenty (10) minutes each to complete. The interviews will be about one (1) hour long. And the training will take up seven (7) hours each Saturday from 9am - 4pm. The interviews will be conducted via zoom while the interaction with the fAEC-KLM will be conducted at North Carolina Agricultural and Technical State University campus, Greensboro, NC.

Risks or Discomforts:
There are no anticipated risks in this study. However, if at any time during this study your child feels uncomfortable, she may discontinue participation either temporarily or permanently.

Benefits of the Study:
Although there will be no direct benefit to your child for taking part in this study, the study may help us learn more about the impact this study has, to inform the development of curriculums/programs

Compensation:
An incentive of $100 will be provided to your child after full participation in this study. Please note that this incentive will be given to your child only if she has a 100% participation in this study.

Confidentiality:
All information collected in this study will be kept strictly confidential to the extent permitted by law. At no time will your child's actual identity be revealed. She will be assigned a random numerical code. The key linking the code to her name will be kept in a secure location and no one else will have access to it. The code key will be destroyed at the end of the research study. Also, the data will be stored on a password protected computer. Your child's name or any information that would identify her will not be used in publications or presentations.
The information that your child gives in the study will be anonymous. Your child's name will not be collected or linked to her answers. With your permission, I would like to take video recordings of your child during the interviews and training. Only the researchers in this study will have access to the video. Once I have analyzed them, the recordings will be destroyed.

□ Yes, you may audio/video record my child.
□ No, you may not audio/video record my child.

_____ Date: _____
Signature of Parent/Legal Guardian

Compensation for Injury:
It is unlikely that participation in this project will result in harm to participants. If any complications arise, we will assist your child in obtaining appropriate attention. If your child needs treatment or hospitalization as a result of being in this study, you are responsible for payment of the cost for that care. If you have insurance, you may bill your insurance company.

You will have to pay any costs not covered by your insurance. North Carolina A&T State University will not pay for any care, lost wages, or provide other financial compensation.

Voluntary Nature of Participation:
Participation in this study is voluntary. If you decide to allow your child to participate, you are free to withdraw her at any time. Your child may also refuse to participate or discontinue participation at any time. Not participating will in no way affect your child's grade or status as a student or result in loss of benefits or services to which your child is otherwise entitled.

Questions about the Study:
If you have any questions about your child's involvement in this project, you may contact the researcher, Mercy Fash at mffash@aggies.ncat.edu or her advisor at andreo@ncat.edu.

If you have any study-related concerns or any questions about your child's rights as a research study participant, you may contact the Office of Research Compliance and Ethics at North Carolina A&T State University at 336-285-3179 or email rescomp@ncat.edu.

Statement of Consent:
I have read the above information and have received answers to any questions I had. I am at least 18 years of age or older and voluntarily consent to have my child take part in this study.

_____
Printed Name of Child

_____
Printed Name of Parent/Legal Guardian

_____ Date: _____
Signature of Parent/Legal Guardian

_____ Date: _____
Principal Investigator

Appendix A.5: Pre-Intervention Interview

Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls

INITIAL INTERVIEW QUESTIONS

Good morning/Afternoon: I am Ms. Mercy Fash a graduate student in the Applied Science and Technology PhD program with the College of Science and Technology at North Carolina A & T State University. I am the PI for this research which is a partial fulfillment of the requirements for my degree of Doctor of Philosophy in Applied Science and Technology.

Thank you for your interest in participating in this research study that seeks to understand the impact of a femalized Architecture, Engineering and Construction Kinesthetic Learning Model (fAEC-KLM) on AEC career interest development in African American middle school girls. The purpose of this interview is to understand how personal identities and characteristics interact with learning experiences in the fAEC-KLM and contributes to AEC career interest development in African American middle school girls. You have been asked to participate if you are an African American middle school girl enrolled in any middle school within Guilford County. You must be between ages 11 and 15 to participate in this research project.

Before we begin, I want to stress the importance of confidentiality. The responses that you share will not be used against you in any way. All of your responses will be recorded via note taking, ZOOM communications software, and later transcribed for analysis. The recordings will be used solely for this project and will be destroyed three years after the end of this study. As a means to ensure your confidentiality, only the PI and her research team will have access to this data. We will not use your name in any report or publication. During this interview, you will have the opportunity to withdraw any specific comment. You can use the term 'off the record' if you do not want me to record or type a specific response.

There are several questions that I would like to ask you. During this interview, some responses may require additional questions to obtain a point of clarity. The information, opinions, and thoughts that you provide will be combined with information from other interviews in order for us to document common themes. If you wish to end the interview at any time or do not want any of your responses to be included in the final analysis, please let us know.
Do you have any questions or concerns before we begin?

INTERVIEW QUESTIONS

1. Tell me about yourself.
2. Explain your salient career identity type (Select one from the model below)
3. What are the important aspects of yourself that you will incorporate into your future career?
4. How has your gender and race influenced your top career choices?

5. Tell me what you know about female and African American participation in AEC careers.
6. On a ranking scale of 1 (lowest) to 5 (highest), to what extent do you think you have the knowledge needed to make a decision about pursuing an AEC career? Explain how lived and learning experiences have contributed to your rank.
7. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you confident that you can become an Architecture, Engineering, or Construction (AEC) professional? Explain how lived and learning experiences have contributed to your rank.
8. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you confident that you will benefit from becoming an Architecture, Engineering, and Construction (AEC) professional? Explain how lived and learning experiences have contributed to your rank.
9. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you interested in pursuing an Architecture, Engineering, or Construction (AEC) career? Explain how lived and learning experiences have contributed to your rank.
10. Have you ever been engaged in a femalized Architecture Engineering and Construction Kinesthetic Learning Model (fAEC-KLM)? YES or NO
11. If yes, answer the following:
    a. Explain aspects of yourself that interacted positively with the fAEC-KLM?
    b. Explain aspects of yourself that interacted negatively with the fAEC-KLM?
    c. How did the most effective components of the fAEC-KLM contribute to increasing knowledge needed to make AEC career decisions?
    d. How did the most effective components of the fAEC-KLM contribute to increasing your interest in becoming a future female and African American AEC professional?
    e. How did the most effective components of the fAEC-KLM contribute to increasing your confidence in becoming a future female and African American AEC professional?
    f. How did the most effective components of the fAEC-KLM contribute to increasing your perception of the benefits that you will gain from becoming a future female and African American AEC professional?
12. Provide recommendations on how AEC career interest development can be increased in African American girls.
13. Do you have any questions for me?

Thank you for your time and participation. Do you have any questions?

Appendix A.6: Pre-Survey

Start of Block: Block 4

Study title: DEVELOPMENT OF A FEMALIZED KINESTHETIC LEARNING MODEL TO INCREASE ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) CAREER INTERESTS IN AFRICAN AMERICAN MIDDLE SCHOOL GIRLS

This pre-survey is designed to measure the interactions AEC learning experiences has on the AEC career-related knowledge, self-efficacy, outcome expectations, and interests of African American middle school girls. The information you provide will be useful in improving learning experiences that increase AEC career interest in females. The estimated time for this pre-survey is 10 minutes. Please responds as honestly as possible, relying on your current feelings and knowledge of the particular issue raised. Select the responses that best apply to you and use short statements to respond to open ended questions. Your responses will be kept confidential.

Mercy Fash
September 2022

Q2 Participant's name: Type your name in the space below.

_____

Q3 Participant's signature: Provide your signature in the space below.

Q4 Type in today's date in the space below

_____

End of Block: Block 4

Start of Block: Default Question Block

Q6 **Section 2: Demographics**

FULL NAME (First Name, Last Name)

_____

Q7 NAME OF MIDDLE SCHOOL

_____

Q8 I am a middle school girl

- ○ True
- ○ False

Q9 AGE

- ○ 10 years old
- ○ 11 years old
- ○ 12 years old
- ○ 13 years old
- ○ Other, Please state _____

Q10 GRADE

- ○ 5th
- ○ 6th
- ○ 7th
- ○ 8th

Q11 Disability status

- ○ Yes, I have a disability. Please, state the disability

_____

- ○ No, I do not have any disability
- ○ I choose not to answer

Q22 What religion family do you belong to or identity yourself most close to?

- ○ Muslim
- ○ Jewish
- ○ Christian (Catholic, Protestant, or any other Christian denominations)
- ○ Hindu
- ○ Buddhist
- ○ I am not Religions
- ○ Other, please specify _____

Q23 What political affiliation do you belong to or identity yourself most close to?

- ○ Democrat
- ○ Republican
- ○ Independent
- ○ Other, please specify _____

Page Break

Q12 EDUCATION LEVEL OF HOUSEHOLD MEMBERS: One of the people I live with has a(n)

- ○ High School Diploma
- ○ Associate's degree
- ○ Bachelor's degree
- ○ Master's degree
- ○ Doctoral degree
- ○ I do not know

Q13 STEM EMPLOYMENT STATUS OF HOUSEHOLD MEMBERS: One of the people I live with works in the Science, Technology, Engineering, and Mathematics (STEM) industry:

- ○ True
- ○ False
- ○ I do not know

Q14 AEC EMPLOYMENT STATUS OF HOUSEHOLD MEMBERS: One of the people I live with works in the Architecture, Engineering, or Construction (AEC) industry:

- ○ True
- ○ False
- ○ I do not know

Q15 What is your annual household income?

- ○ 25k or less
- ○ 26k-50k
- ○ 51k-75k
- ○ 76k-100k
- ○ 101k-125k

- ○ 126k-150k
- ○ 151k-170k
- ○ 171k-199k
- ○ 200k or more

End of Block: Default Question Block

Start of Block: Block 7

Q16 **Section 3: AEC Career Interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in Architecture or Design careers	○	○	○	○	○
I am interested in Architectural Engineering careers	○	○	○	○	○
I am interested in Civil Engineering careers	○	○	○	○	○
I am interested in Environmental Engineering careers	○	○	○	○	○
I am interested in a Construction career	○	○	○	○	○

Q17 **Section 4: Learning Experiences and AEC career interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I enjoy being creative	○	○	○	○	○
I am interested in AEC careers because I enjoy observing objects in my environment	○	○	○	○	○
I am interested in AEC careers because I enjoy hands-on projects	○	○	○	○	○
I am interested in AEC careers because I enjoy problem solving	○	○	○	○	○
I am interested in AEC careers because I enjoy	○	○	○	○	○

working with my peers on AEC projects					
I am interested in AEC careers because I am inspired by female AEC role models	○	○	○	○	○
I am interested in AEC careers because I am inspired by African American female AEC role models	○	○	○	○	○
I am interested in AEC careers because I enjoy developing project reports from buildings, bridges, etc.	○	○	○	○	○
I am interested in AEC careers because I enjoy learning from AEC professionals	○	○	○	○	○
I am interested in AEC careers because I enjoy working in	○	○	○	○	○

building environments

End of Block: Block 7

Start of Block: Block 5

Q18 The following listed activities to the left are related to the femalized AEC kinesthetic learning model. Using the numbers below as ranking levels, pick and rank each activity based on how effective they are in increasing career interests in African American middle school girls.

Please rank the activities based on your current knowledge of all the activities.

_____ Lecture on AEC and fAEC-KLM
_____ Lecture on salary benefits of AEC professionals
_____ Lecture on bridge design and construction
_____ Documentary of female African American AEC professionals
_____ Success stories of female African American AEC undergraduate students on journeys from childhood to being an AEC student
_____ Mathematical calculations for bridges
_____ Bridge Design
_____ Bridge Construction
_____ Teamwork
_____ Incorporation of feminine products to project design and construction
_____ Lunch break
_____ Project presentation
_____ Interaction with peers
_____ Interaction with instructors
_____ Interaction with teammates
_____ Response to questions asked
_____ Awards ceremony
_____ Lecture on self-efficacy and identity
_____ Interaction with undergraduate panelists
_____ Classroom setting

End of Block: Block 5

Start of Block: Block 6

Q19 **Section 5: Knowledge**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I know AEC roles and responsibilities	○	○	○	○	○
I am interested in AEC careers because I know AEC industry impacts	○	○	○	○	○
I am interested in AEC careers because I know AEC career benefits	○	○	○	○	○
I am interested in AEC careers because I know about successful female AEC professionals	○	○	○	○	○
I am interested in AEC careers because I know about successful African American AEC female professionals	○	○	○	○	○
I am interested in AEC careers because I know about the underrepresentation of females in AEC professions	○	○	○	○	○
I am interested in AEC careers because I know about the	○	○	○	○	○

underrepresentation of African Americans in AEC professions

Q20 **Section 6: Self-efficacy and AEC career interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I can develop hands-on projects	○	○	○	○	○
I am interested in AEC careers because I can develop creative projects	○	○	○	○	○
I am interested in AEC careers because I can solve math problems	○	○	○	○	○
I am interested in AEC careers because I can solve science projects	○	○	○	○	○

I am interested in AEC careers because I can develop art projects	○	○	○	○	○
I am interested in AEC careers because I can contribute female perspectives towards the development of built environments	○	○	○	○	○
I am interested in AEC careers because I can contribute African American perspectives towards the development of built environments	○	○	○	○	○
I am interested in AEC careers because I can learn from AEC role models	○	○	○	○	○
I am interested in AEC careers because I can work with different team members	○	○	○	○	○

I am interested in AEC careers because I can work in challenging AEC industry environments	○	○	○	○	○

End of Block: Block 6

Start of Block: Block 7

Q21 **Section 7: Outcome Expectations**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I will have a high paying job	○	○	○	○	○
I am interested in AEC careers because I will be respected by many	○	○	○	○	○
I am interested in AEC careers because I will contribute to increasing female representation in AEC careers	○	○	○	○	○

I am interested in AEC careers because I will contribute to increasing African American representation in AEC careers.	○	○	○	○	○
I am interested in AEC careers because I will contribute to eradicating AEC workforce shortages	○	○	○	○	○
I am interested in AEC careers because I will be a trail blazer like other African American female AEC role models.	○	○	○	○	○
I am interested in AEC careers because I will impact the environment.	○	○	○	○	○
I am interested in AEC careers because I feel a connection between by socio-cultural (e.g.,	○	○	○	○	○

Religion) identity and AEC career outcomes

End of Block: Block 7

Appendix A.7: Pre-test

Study title: **DEVELOPMENT OF A FEMALIZED KINESTHETIC LEARNING MODEL TO INCREASE ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) CAREER INTERESTS IN AFRICAN AMERICAN MIDDLE SCHOOL GIRLS**

This pre-test is designed to measure the interactions AEC learning experiences has on the AEC career-related knowledge, self-efficacy, outcome expectations, and interests of African American middle school girls. The information you provide will be useful in improving learning experiences that increase AEC career interest in females. The estimated time for this pre-test is 10 minutes. Please complete all items on this pre-test by selecting the most responsive answer to each of the questions or typing your answer in the space provided.

Mercy Fash
September 2022

Full Name
_____

Today's date: Type in today's date in the space below.
_____

Q6 Age

- ○ 10 Years old
- ○ 11 Years old
- ○ 12 Years old
- ○ 13 Years old
- ○ Other, please state _____

Q7 Grade

- ○ 6th

- ○ 7th
- ○ 8th

End of Block: Default Question Block

Start of Block: Block 2

Q8 **Section 2. Test**
A. AEC Knowledge

Please provide honest answers to the questions below. Answers should be based on your own knowledge and without use of external sources.

1. AEC stands for _____.

- ○ Astronomy, Educator, Carpenter
- ○ Architecture, Engineering, Construction
- ○ Artist, Entrepreneur, Corsetiere
- ○ I do not know

Q9 2. Architects are responsible for _____ and _____ the construction of buildings.

- ○ dedicating, capsizing
- ○ demolishing, computing
- ○ designing, supervising
- ○ I do not know

Q10 3. Construction engineering is a professional discipline that involves designing, _____, construction, and _____.

- ○ planning, management
- ○ processing, meddling
- ○ poking, manufacturing
- ○ I do not know

Q11 4. AEC professionals are good in what courses?

- ○ Math
- ○ Science
- ○ Technology
- ○ Arts
- ○ Design
- ○ All of the above
- ○ None of the above

Q12 5. African Americans are underrepresented in AEC professions

- ○ True
- ○ Neither true nor false
- ○ False
- ○ I do not know

Q13 6. Some characteristics of AEC professionals are _____

- ○ A. love hands-on projects, analytical, creative
- ○ B. artistic, potter, composer
- ○ C. entrepreneur, love to travel, humanitarian
- ○ A & C
- ○ I do not know

Q14 7. Why is the participation of African American females in AEC professions important?

- ○ A. They provide diversity and inclusion

- B. They help eradicate the underrepresentation of women and workforce shortages in AEC professions
- C. They help occupy space
- D. Only A & B
- E. I do not know

Q15 8. What percentage of females are represented in Architecture and engineering professions?

- 6%
- 27%
- 14%
- I do not know

Q16 9. Why is the participation of women in AEC professions important?

- A. To make the world more femalized
- B. To eradicate the underrepresentation of women in AEC professions
- C. To eradicate workforce shortages in AEC professions
- B & C
- I do not know

Q17 10. Which of the following females was the first licensed black female architect in the state of New York?

- Dolly Paton
- Kamala Harris
- Norma Sklarek
- Janine Sklora
- I do not know

Q18 11. STEM stands for _____

- Study, Teach, Exercise, Meditate
- Social, Team, Empathy, Mold
- Science, Technology, Engineering, Mathematics
- I do not know

Q19 12. Which of these tools can be used for drawing?

- Architect's scale
- AutoCAD software
- All of the above
- I do not know

Q20 Amanda is an AEC student who loves to travel. She has been to seven different countries and two continents. During her travels, she envisions how she can beautify her community based on the beautiful buildings she has seen in other countries. Based on Amanda's interest, she can be referred to as an AEC _____?

- Entrepreneur
- Minority advocate
- Globalist
- Missionary
- I do not know

Q21 13. Which of the following best describes kinesthetic learning?

- Hands-on learning
- Learning by reading or writing

- ○ Learning by visuals
- ○ Learning by listening
- ○ I do not know

Q22 Keisha is a high school girl whose family migrated from Africa. She loves to create building designs inspired by her heritage. In the future, she hopes to be an AEC advocate for immigrants and also educate others on the importance of diversity in AEC professions. Keisha can be referred to as an AEC _____?

- ○ Immigrant Advocate
- ○ Youth Advocate
- ○ Humanitarian
- ○ Feminist
- ○ I do not know

Q23 14. In 1991 who founded the National Association of Black Women in Construction (NABWIC)?

- ○ Beverly Loraine Green
- ○ Norma Merrick Sklarek
- ○ Ann McNeil
- ○ I do not know

Q24 15. What is the average annual income of a professional architect in North Carolina?

- ○ $70,000
- ○ $92,000
- ○ $104,038
- ○ $84,000
- ○ I do not know

Q25 16. What is the average annual income of a professional construction manager?

- ○ $100,000
- ○ $97,000
- ○ $76,000
- ○ $112,579
- ○ I do not know

Page Break

Q26 **Section 3. Bridge Construction**

Please provide honest answers to the questions below. Answers should be based on your own knowledge and without use of external sources.

1. What holds a structure to the ground?

- ○ Superstructure
- ○ Foundation
- ○ Beams
- ○ I do not know

Q27 2. Which of these forces act on bridges?

- ○ A. compression and tension
- ○ B. Torsion and shear
- ○ C. Kinetic and Potential
- ○ D. Just A & B
- ○ E. All of the above
- ○ F. I do not know

Q28 3. Forces acting on bridges help to _____?

- ○ make the bridges beautiful
- ○ make the bridges well balanced and stand efficiently
- ○ push air out of the bridges
- ○ I do not know

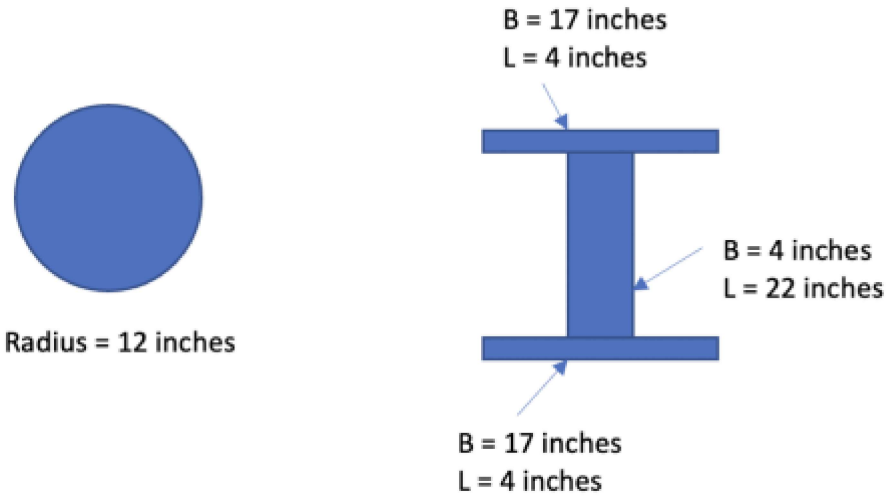
Q29 4. How many inches are in 3ft?

- ○ 24 inches
- ○ 36 inches
- ○ 48 inches
- ○ I do not know

Q30 5. How many meters are in 520cm?

- ○ 5 meters
- ○ 52 meters
- ○ 5.2 meters
- ○ I do not know

Q31 For Questions 6 - 10, use the diagrams below as a reference to answer the questions.



6. For the diagram above, given that:
π x (radius)2 Take π = 3.14
What is the cross-sectional area of the circle?

- 314.0 in^2
- 728.26 in^2
- 452.16 in^2
- I do not know

Q32 7. What is the cross-sectional area of the I-beam above?

- 176.5 in^2
- 224 in^2
- 230.72 in^2
- I do not know

Q33 8. If there is a maximum tensile strength of 3,755 lb/in^2, what is the maximum tensile force of the circle?

- ○ 1,697,860.8 lbs
- ○ 1,776,284.55 lbs
- ○ 1,595,100.9 lbs
- ○ I do not know

Q34 9. If there is a maximum compressive strength of 4.855 lb/in^2, what is the maximum compressive force of the circle?

- ○ 3,860,152.90 lbs
- ○ 2,195,236.8 lbs
- ○ 2,000.065.7 lbs
- ○ I do not know

Q35 10. What is the maximum compressive force of the I-beam?

- ○ 1,087,520 lbs
- ○ 1,900,854 lbs
- ○ 1,745,921 lbs
- ○ I do not know

Q36 11. The three main types of load engineers consider when constructing bridges are:

- ○ Live loads, dead loads, dynamic loads
- ○ deal loads, human loads, combative loads
- ○ moral loads, weight loads, resistance loads
- ○ I do not know

Q37 12. The following are considered loads on a bridge except?

- ○ Humans

- House
- Vehicles
- Snow
- I do not know

Q38 13. Steel is widely used around the world for the construction of bridges. Which of the following statements is true about steel?

- A. steel is light weight
- B. Steel saves costs significantly
- C. Steel is the most recycled material in the world
- D. All of the above
- E. Only A & B
- F. I do not know

Q39 More steel is recycled every year than paper, glass, aluminum, and plastic combined.

- True
- Neither true nor false
- False
- I do not know

Appendix B: fAEC-KLM

Appendix B.1: Scheduled Activities for fAEC-KLM

DAYS	ACTIVITIES
1ST SATURDAY	• 9am – 10 am: Orientation and code of conduct • 10 am – 11am Completion of pre-survey and pre-test • 11 am – 12 pm: Lecture on Self-efficacy and Identity • 12 pm – 1pm: Lunch break • 1pm – 3pm: Lecture on AEC and fAEC-KLM • 3pm – 4pm: Lecture on Bridge Construction
2ND SATURDAY	• 9am – 10am: Documentary on African American female AEC professions • 10am – 12pm: Development of individual designs • 12pm – 1pm: Lunch break • 1pm – 3pm: Team pairing and final project planning • 3pm – 4pm: Interactive session with teammates
3RD SATURDAY	• 9am – 10am: Sorting out of materials for bridge project • 10am – 12pm: Teams working on project • 12pm – 1pm: Lunch break • 1pm – 3pm: Panel session with AEC female undergraduates • 3pm – 4pm: Interaction with AEC panelists
4TH SATURDAY	• 9am – 12pm: Final touches on project • 12pm – 1pm: Lunch break • 1pm – 3pm: Presentation plan • 3pm – 4pm: Interactive session with participants
5TH SATURDAY	• 10am – 12pm: Project presentation • 12pm – 1pm: Lunch break

	• 1pm – 2pm: Completion of post-survey and post-test

Appendix B.2: Observation Protocol

The observation protocol for this study aims to validate the abilities and attributes displayed by RPs in the different AEC career interest categories. All activities within the 5-day program are recorded"
6hrs per day for 5 days =30 hours of recording.

Using the results from interviews, surveys, and tests, activities for one participant from each interest group are tracked and translated to document how much time is spent carrying out activities related to the most effective components of the fAEC-KLM.

Tracked videos will be translated using a template created on Virtual Timing Application (VTA). VTA will track if participant is engaged or engaged during activities within the most effective components.

File updated – 6/18/2024

After determining the three AEC career interest categories from the results, the observation protocol is updated as follows:

AEC Career Interest Categories	Career-Relevant Self-Attribute
Active	Creative Abilities
Passive	Analytical Abilities
Null	Social Abilities

Participants are tracked based on "Engaged" and "Unengaged."

Engaged:	Participant is carrying out an activity related to the discussed effective component of the fAEC-KLM.
Unengaged:	Participant is carrying out an activity that is not related to the effective component of the fAEC-KLM.

Top three most effective components of the fAEC-KLM and most frequent activities captured within them are:

AEC Lectures:

Note_Taking	Actively taking notes during lectures
Asking_Questions	Seeking clarity from instructor or peers during lectures
Answering_Questions	Providing answers to questions asked by instructor or peers
Agreeing_to_Statements	Agreeing to statements made by instructor or peers
Peer_Interaction	Maintaining or having lecture-related conversations with peers
Distracted	Doing something else other than all other activities listed here.

Bridge Construction Project:

Kinesthetic	Actively working on bridge construction

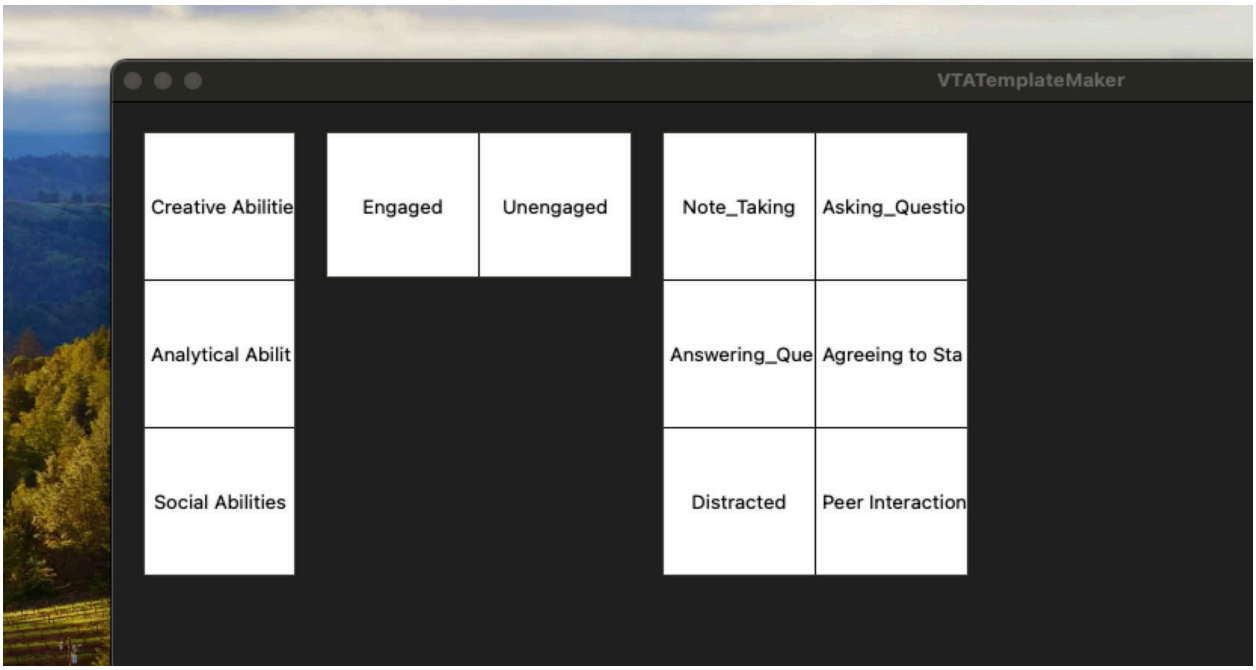
Team_Interaction	Actively communicating with teammate while working on bridge project
Leadership	Taking lead on bridge project while teammate watches
Design	Actively sketching or describing what bridge should look like to teammate.
Problem-solving	Providing a solution to a problem encountered during project
Independent	Working on project alone without teammate nearby
Math	Actively calculating math related to bridge project
Inquisitive	Asking teammate or instructor for clarification or insight into project
Helping_Others	Assisting other teams with bridge project
Providing_Ideas	Actively providing suggestion on how best to carryout project
Critical_Thinking	Actively brainstorming with teammate on how to make project better
Decision_Making	Agreeing or deciding on suggestions made with teammate

Peer Interactions:

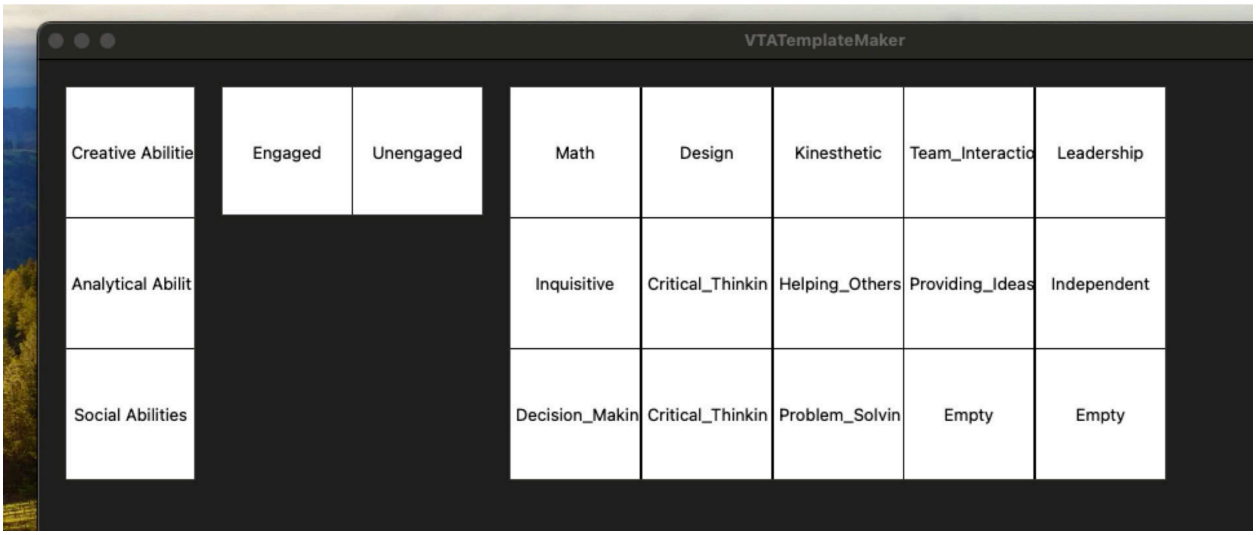
Conversation_with_Peers	Having conversations with other girls in the room
Conversation_with_Teammate	Having conversations exclusively with teammate
Listening	Actively listening to conversations with teammate or peers
By_self	Sitting alone away from others – engaged in another activity
Uninteractive	Sitting with a group but not participating in conversations

Templates:

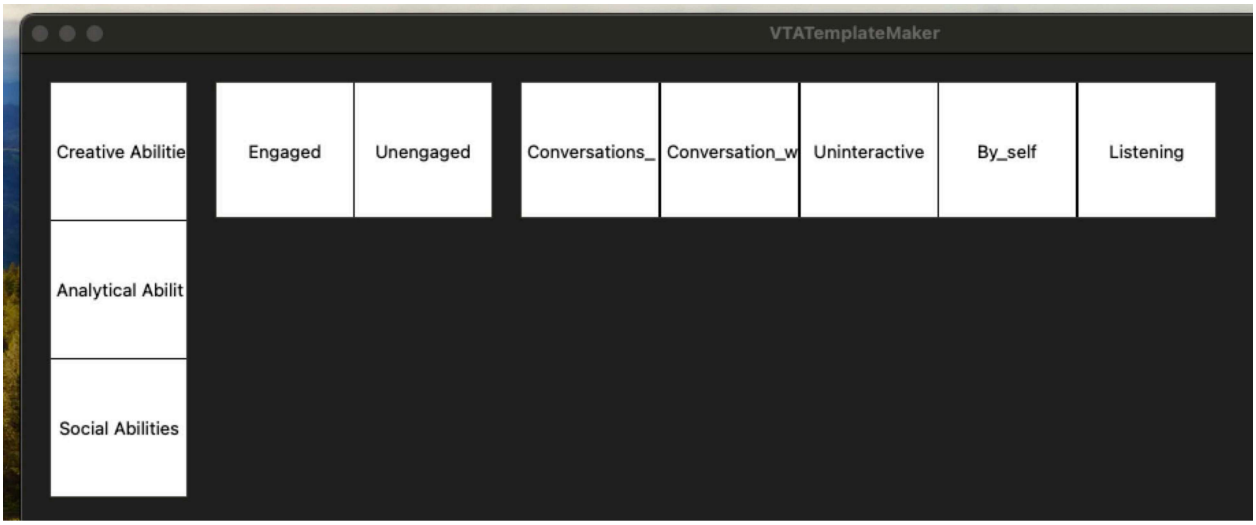
AEC Lectures



Bridge Construction Project



Peer Interactions



Appendix C: Post-Intervention Tools

Appendix C.1: Post-survey

Start of Block: Block 4

Study title: DEVELOPMENT OF A FEMALIZED KINESTHETIC LEARNING MODEL TO INCREASE ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) CAREER INTERESTS IN AFRICAN AMERICAN MIDDLE SCHOOL GIRLS

This post-survey is designed to measure the interactions AEC learning experiences has on the AEC career-related knowledge, self-efficacy, outcome expectations, and interests of African American middle school girls. The information you provide will be useful in improving learning experiences that increase AEC career interest in females. The estimated time for this post-survey is 10 minutes. Please responds as honestly as possible, relying on your current feelings and knowledge of the particular issue raised. Select the responses that best apply to you and use short statements to respond to open ended questions. Your responses will be kept confidential.

Mercy Fash
September 2022

Q2 Participant's name: Type your name in the space below.

_____

Q3 Participant's signature: Provide your signature in the space below.

Q4 Type in today's date in the space below

_____

Q5 Signed by Mercy Fash
Principal Investigator, August 2022

End of Block: Block 4

Start of Block: Default Question Block

Q6 **Section 2: Demographics**

FULL NAME (First Name, Last Name)

_____

Q7 NAME OF MIDDLE SCHOOL

_____

Q8 I am a middle school girl

- ○ True
- ○ False

Q9 AGE

- ○ 10 years old
- ○ 11 years old
- ○ 12 years old
- ○ 13 years old
- ○ Other, Please state _____

Q10 GRADE

- ○ 5th
- ○ 6th
- ○ 7th
- ○ 8th

Q11 Disability status

- ○ Yes, I have a disability. Please, state the disability _____
- ○ No, I do not have any disability
- ○ I choose not to answer

Q22 What religion family do you belong to or identity yourself most close to?

- ○ Muslim
- ○ Jewish
- ○ Christian (Catholic, Protestant, or any other Christian denominations)
- ○ Hindu
- ○ Buddhist
- ○ I am not Religions
- ○ Other, Please specify _____

Q23 What political affiliation do you belong to or identity yourself most close to?

- ○ Democrat
- ○ Republican
- ○ Independent
- ○ Other, Please specify _____

Q12 EDUCATION LEVEL OF HOUSEHOLD MEMBERS: One of the people I live with has a(n)

- ○ High School Diploma
- ○ Associate's degree
- ○ Bachelor's degree
- ○ Master's degree

- ○ Doctoral degree
- ○ I do not know

Q13 STEM EMPLOYMENT STATUS OF HOUSEHOLD MEMBERS: One of the people I live with works in the Science, Technology, Engineering, and Mathematics (STEM) industry:

- ○ True
- ○ False
- ○ I do not know

Q14 AEC EMPLOYMENT STATUS OF HOUSEHOLD MEMBERS: One of the people I live with works in the Architecture, Engineering, or Construction (AEC) industry:

- ○ True
- ○ False
- ○ I do not know

Q15 What is your annual household income?

- ○ 25k or less
- ○ 26k-50k
- ○ 51k-75k
- ○ 76k-100k
- ○ 101k-125k
- ○ 126k-150k
- ○ 151k-170k
- ○ 171k-199k
- ○ 200k or more

End of Block: Default Question Block

Start of Block: Block 7

Q16 **Section 3: AEC Career Interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in Architecture or Design careers	○	○	○	○	○
I am interested in Architectural Engineering careers	○	○	○	○	○
I am interested in Civil Engineering careers	○	○	○	○	○
I am interested in Environmental Engineering careers	○	○	○	○	○
I am interested in a Construction career	○	○	○	○	○

Q17 **Section 4: Learning Experiences and AEC career interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I enjoy being creative	○	○	○	○	○
I am interested in AEC careers because I enjoy observing objects in my environment	○	○	○	○	○
I am interested in AEC careers because I enjoy hands-on projects	○	○	○	○	○
I am interested in AEC careers because I enjoy problem solving	○	○	○	○	○
I am interested in AEC careers because I enjoy working with my peers on AEC projects	○	○	○	○	○
I am interested in AEC careers because I am inspired by	○	○	○	○	○

female AEC role models					
I am interested in AEC careers because I am inspired by African American female AEC role models	○	○	○	○	○
I am interested in AEC careers because I enjoy developing project reports from buildings, bridges, etc.	○	○	○	○	○
I am interested in AEC careers because I enjoy learning from AEC professionals	○	○	○	○	○
I am interested in AEC careers because I enjoy working in building environments	○	○	○	○	○

End of Block: Block 7

Start of Block: Block 5

Q18 The following listed activities to the left are related to the femalized AEC kinesthetic learning model. Using the numbers below as ranking levels, pick and rank each activity based on how effective they are in increasing career interests in African American middle school girls.

Please rank the activities based on your current knowledge of all the activities.

_____ Lecture on AEC and fAEC-KLM
_____ Lecture on salary benefits of AEC professionals
_____ Lecture on bridge design and construction
_____ Documentary of female African American AEC professionals
_____ Success stories of female African American AEC undergraduate students on journeys from childhood to being an AEC student
_____ Mathematical calculations for bridges
_____ Bridge Design
_____ Bridge Construction
_____ Teamwork
_____ Incorporation of feminine products to project design and construction
_____ Lunch break
_____ Project presentation
_____ Interaction with peers
_____ Interaction with instructors
_____ Interaction with teammates
_____ Response to questions asked
_____ Awards ceremony
_____ Lecture on self-efficacy and identity
_____ Interaction with undergraduate panelists
_____ Classroom setting

Q19 **Section 5: Knowledge**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I know AEC roles and responsibilities	○	○	○	○	○
I am interested in AEC careers because I know AEC industry impacts	○	○	○	○	○

I am interested in AEC careers because I know AEC career benefits	○	○	○	○	○
I am interested in AEC careers because I know about successful female AEC professionals	○	○	○	○	○
I am interested in AEC careers because I know about successful African American AEC female professionals	○	○	○	○	○
I am interested in AEC careers because I know about the underrepresentation of females in AEC professions	○	○	○	○	○
I am interested in AEC careers because I know about the underrepresentation of African Americans in AEC professions	○	○	○	○	○

Q20 **Section 6: Self-efficacy and AEC career interests**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I can develop hands-on projects	○	○	○	○	○
I am interested in AEC careers because I can develop creative projects	○	○	○	○	○
I am interested in AEC careers because I can solve math problems	○	○	○	○	○
I am interested in AEC careers because I can solve science projects	○	○	○	○	○
I am interested in AEC careers because I can develop art projects	○	○	○	○	○
I am interested in AEC careers because I can contribute female perspectives towards the	○	○	○	○	○

development of built environments					
I am interested in AEC careers because I can contribute African American perspectives towards the development of built environments	○	○	○	○	○
I am interested in AEC careers because I can learn from AEC role models	○	○	○	○	○
I am interested in AEC careers because I can work with different team members	○	○	○	○	○
I am interested in AEC careers because I can work in challenging AEC industry environments	○	○	○	○	○

End of Block: Block 6

Start of Block: Block 7

Q21 **Section 7: Outcome Expectations**

Using the 5-point scale in the table below, indicate your level of agreement to the statements in the first column of the table below. Select the option that best reflects your opinion.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am interested in AEC careers because I will have a high paying job	○	○	○	○	○
I am interested in AEC careers because I will be respected by many	○	○	○	○	○
I am interested in AEC careers because I will contribute to increasing female representation in AEC careers	○	○	○	○	○
I am interested in AEC careers because I will contribute to increasing African American representation in AEC careers.	○	○	○	○	○
I am interested in AEC careers	○	○	○	○	○

because I will contribute to eradicating AEC workforce shortages					
I am interested in AEC careers because I will be a trail blazer like other African American female AEC role models.	○	○	○	○	○
I am interested in AEC careers because I will impact the environment.	○	○	○	○	○
I am interested in AEC careers because I feel a connection between by socio-cultural (e.g., Religion) identity and AEC career outcomes	○	○	○	○	○

End of Block: Block 7

Appendix C.2: Post-test

Study title: **DEVELOPMENT OF A FEMALIZED KINESTHETIC LEARNING MODEL TO INCREASE ARCHITECTURE, ENGINEERING, AND CONSTRUCTION (AEC) CAREER INTERESTS IN AFRICAN AMERICAN MIDDLE SCHOOL GIRLS**

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Full Name

_____

Today's date: Type in today's date in the space below.

_____

Q5 Signed by
Mercy Fash
Principal Investigator, September 2022

Q6 Age

- ○ 10 Years old
- ○ 11 Years old
- ○ 12 Years old
- ○ 13 Years old
- ○ Other, please state _____

Q7 Grade

- ○ 6th
- ○ 7th
- ○ 8th

End of Block: Default Question Block

Start of Block: Block 2

Q8 **Section 2. Test**
A. AEC Knowledge

Please provide honest answers to the questions below. Answers should be based on your own knowledge and without use of external sources.

1. AEC stands for _____.

- ○ Astronomy, Educator, Carpenter
- ○ Architecture, Engineering, Construction
- ○ Artist, Entrepreneur, Corsetiere
- ○ I do not know

Q9 2. Architects are responsible for _____ and _____ the construction of buildings.

- ○ dedicating, capsizing
- ○ demolishing, computing
- ○ designing, supervising
- ○ I do not know

Q10 3. Construction engineering is a professional discipline that involves designing, _____, construction, and _____.

- ○ planning, management
- ○ processing, meddling
- ○ poking, manufacturing

- ○ I do not know

Q11 4. AEC professionals are good in what courses?

- ○ Math
- ○ Science
- ○ Technology
- ○ Arts
- ○ Design
- ○ All of the above
- ○ None of the above

Q12 5. African Americans are underrepresented in AEC professions

- ○ True
- ○ Neither true nor false
- ○ False
- ○ I do not know

Q13 6. Some characteristics of AEC professionals are _____

- ○ A. love hands-on projects, analytical, creative
- ○ B. artistic, potter, composer
- ○ C. entrepreneur, love to travel, humanitarian
- ○ A & C
- ○ I do not know

Q14 7. Why is the participation of African American females in AEC professions important?

- A. They provide diversity and inclusion
- B. They help eradicate the underrepresentation of women and workforce shortages in AEC professions
- C. They help occupy space
- D. Only A & B
- E. I do not know

Q15 8. What percentage of females are represented in Architecture and engineering professions?

- 6%
- 27%
- 14%
- I do not know

Q16 9. Why is the participation of women in AEC professions important?

- A. To make the world more femalized
- B. To eradicate the underrepresentation of women in AEC professions
- C. To eradicate workforce shortages in AEC professions
- B & C
- I do not know

Q17 10. Which of the following females was the first licensed black female architect in the state of New York?

- Dolly Paton
- Kamala Harris
- Norma Sklarek
- Janine Sklora

- ○ I do not know

Q18 11. STEM stands for _____

- ○ Study, Teach, Exercise, Meditate
- ○ Social, Team, Empathy, Mold
- ○ Science, Technology, Engineering, Mathematics
- ○ I do not know

Q19 12. Which of these tools can be used for drawing?

- ○ Architect's scale
- ○ AutoCAD software
- ○ All of the above
- ○ I do not know

Q20 Amanda is an AEC student who loves to travel. She has been to seven different countries and two continents. During her travels, she envisions how she can beautify her community based on the beautiful buildings she has seen in other countries. Based on Amanda's interest, she can be referred to as an AEC _____?

- ○ Entrepreneur
- ○ Minority advocate
- ○ Globalist
- ○ Missionary
- ○ I do not know

Q21 13. Which of the following best describes kinesthetic learning?

- ○ Hands-on learning

- ○ Learning by reading or writing
- ○ Learning by visuals
- ○ Learning by listening
- ○ I do not know

Q22 Keisha is a high school girl whose family migrated from Africa. She loves to create building designs inspired by her heritage. In the future, she hopes to be an AEC advocate for immigrants and also educate others on the importance of diversity in AEC professions. Keisha can be referred to as an AEC _____?

- ○ Immigrant Advocate
- ○ Youth Advocate
- ○ Humanitarian
- ○ Feminist
- ○ I do not know

Q23 14. In 1991 who founded the National Association of Black Women in Construction (NABWIC)?

- ○ Beverly Loraine Green
- ○ Norma Merrick Sklarek
- ○ Ann McNeil
- ○ I do not know

Q24 15. What is the average annual income of a professional architect in North Carolina?

- ○ $70,000
- ○ $92,000
- ○ $104,038
- ○ $84,000

- ○ I do not know

Q25 16. What is the average annual income of a professional construction manager?

- ○ $100,000
- ○ $97,000
- ○ $76,000
- ○ $112,579
- ○ I do not know

Page Break

Q26 **Section 3. Bridge Construction**

Please provide honest answers to the questions below. Answers should be based on your own knowledge and without use of external sources.

1. What holds a structure to the ground?

- ○ Superstructure
- ○ Foundation
- ○ Beams
- ○ I do not know

Q27 2. Which of these forces act on bridges?

- ○ A. compression and tension
- ○ B. Torsion and shear
- ○ C. Kinetic and Potential
- ○ D. Just A & B

- E. All of the above
- F. I do not know

Q28 3. Forces acting on bridges help to _____?

- make the bridges beautiful
- make the bridges well balanced and stand efficiently
- push air out of the bridges
- I do not know

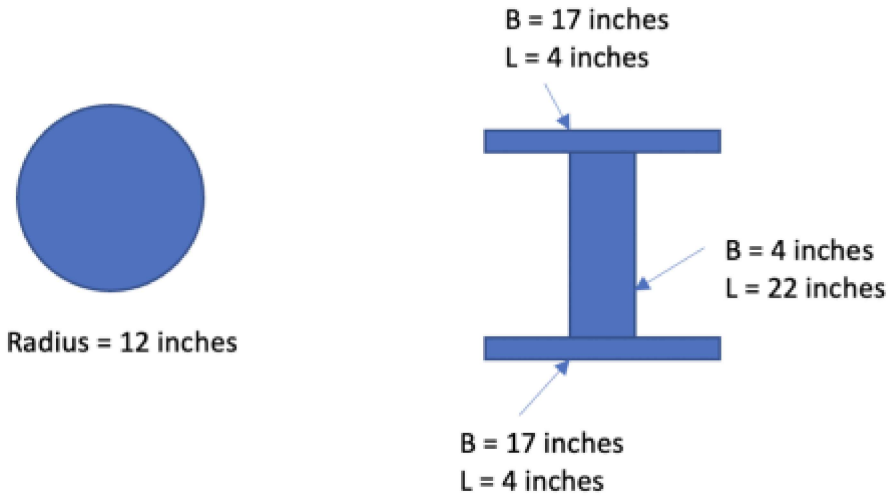
Q29 4. How many inches are in 3ft?

- 24 inches
- 36 inches
- 48 inches
- I do not know

Q30 5. How many meters are in 520cm?

- 5 meters
- 52 meters
- 5.2 meters
- I do not know

Q31 For Questions 6 - 10, use the diagrams below as a reference to answer the questions.



6. For the diagram above, given that:
π x (radius)2 Take π = 3.14
What is the cross-sectional area of the circle?

- 314.0 in^2
- 728.26 in^2
- 452.16 in^2
- I do not know

Q32 7. What is the cross-sectional area of the I-beam above?

- 176.5 in^2
- 224 in^2
- 230.72 in^2
- I do not know

Q33 8. If there is a maximum tensile strength of 3,755 lb/in^2, what is the maximum tensile force of the circle?

- 1,697,860.8 lbs
- 1,776,284.55 lbs
- 1,595,100.9 lbs
- I do not know

Q34 9. If there is a maximum compressive strength of 4.855 lb/in^2, what is the maximum compressive force of the circle?

- 3,860,152.90 lbs
- 2,195,236.8 lbs
- 2,000.065.7 lbs
- I do not know

Q35 10. What is the maximum compressive force of the I-beam?

- 1,087,520 lbs
- 1,900,854 lbs
- 1,745,921 lbs
- I do not know

Q36 11. The three main types of load engineers consider when constructing bridges are:

- Live loads, dead loads, dynamic loads
- deal loads, human loads, combative loads
- moral loads, weight loads, resistance loads
- I do not know

Q37 12. The following are considered loads on a bridge except?

- Humans

- House
- Vehicles
- Snow
- I do not know

Q38 13. Steel is widely used around the world for the construction of bridges. Which of the following statements is true about steel?

- A. steel is light weight
- B. Steel saves costs significantly
- C. Steel is the most recycled material in the world
- D. All of the above
- E. Only A & B
- F. I do not know

Q39 More steel is recycled every year than paper, glass, aluminum, and plastic combined.

- True
- Neither true nor false
- False
- I do not know

Appendix C.3: Post-Intervention Interview

Development of a Femalized Kinesthetic Learning Model to Increase Architecture, Engineering, and Construction (AEC) Career Interests in African American Middle School Girls

FINAL INTERVIEW QUESTIONS

Good morning/Afternoon: I am Ms. Mercy Fash a graduate student in the Applied Science and Technology PhD program with the College of Science and Technology at North Carolina A & T State University. I am the PI for this research which is a partial fulfillment of the requirements for my degree of Doctor of Philosophy in Applied Science and Technology.

Thank you for your interest in participating in this research study that seeks to understand the impact of a femalized Architecture, Engineering and Construction Kinesthetic Learning Model (fAEC-KLM) on AEC career interest development in African American middle school girls. The purpose of this interview is to understand how personal identities and characteristics interact with learning experiences in the fAEC-KLM and contributes to AEC career interest development in African American middle school girls. You have been asked to participate if you are an African American middle school girl enrolled in any middle school within Guilford County. You must be between ages 11 and 15 to participate in this research project.

Before we begin, I want to stress the importance of confidentiality. The responses that you share will not be used against you in any way. All of your responses will be recorded via note taking, ZOOM communications software, and later transcribed for analysis. The recordings will be used solely for this project and will be destroyed three years after the end of this study. As a means to ensure your confidentiality, only the PI and her research team will have access to this data. We will not use your name in any report or publication. During this interview, you will have the opportunity to withdraw any specific comment. You can use the term 'off the record' if you do not want me to record or type a specific response.

There are several questions that I would like to ask you. During this interview, some responses may require additional questions to obtain a point of clarity. The information, opinions, and thoughts that you provide will be combined with information from other interviews in order for us to document common themes. If you wish to end the interview at any time or do not want any of your responses to be included in the final analysis, please let us know.
Do you have any questions or concerns before we begin?

INTERVIEW QUESTIONS

1. Tell me about yourself.
2. Explain your salient career identity type (Select one from the model below)
3. What are the important aspects of yourself that you will incorporate into your future career?
4. How has your gender and race influenced your top career choices?
5. Tell me what you know about female and African American participation in AEC careers.

6. On a ranking scale of 1 (lowest) to 5 (highest), to what extent do you think you have the knowledge needed to make a decision about pursuing an AEC career? Explain how lived and learning experiences have contributed to your rank.
7. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you confident that you can become an Architecture, Engineering, or Construction (AEC) professional? Explain how lived and learning experiences have contributed to your rank.
8. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you confident that you will benefit from becoming an Architecture, Engineering, and Construction (AEC) professional? Explain how lived and learning experiences have contributed to your rank.
9. On a ranking scale of 1 (lowest) to 5 (highest), to what extent are you interested in pursuing an Architecture, Engineering, or Construction (AEC) career? Explain how lived and learning experiences have contributed to your rank.
10. Have you ever been engaged in a femalized Architecture Engineering and Construction Kinesthetic Learning Model (fAEC-KLM)? YES or NO
11. If yes, answer the following:
    a. Explain aspects of yourself that interacted positively with the fAEC-KLM?
    b. Explain aspects of yourself that interacted negatively with the fAEC-KLM?
    c. How did the most effective components of the fAEC-KLM contribute to increasing knowledge needed to make AEC career decisions?
    d. How did the most effective components of the fAEC-KLM contribute to increasing your interest in becoming a future female and African American AEC professional?
    e. How did the most effective components of the fAEC-KLM contribute to increasing your confidence in becoming a future female and African American AEC professional?
    f. How did the most effective components of the fAEC-KLM contribute to increasing your perception of the benefits that you will gain from becoming a future female and African American AEC professional?
12. Provide recommendations on how AEC career interest development can be increased in African American girls.
13. Do you have any questions for me?

Thank you for your time and participation. Do you have any questions?

Appendix D: Codebooks for Interview Thematic Analysis

Appendix D.1: AEC Knowledge Codebook

THEME: FAEC-KLM INCREASES AEC KNOWLEDGE IN AFRICAN AMERICAN MIDDLE-SCHOOL GIRLS

SUB-THEME 1 – ATTRIBUTING PRE-INTERVENTION AEC KNOWLEDGE TO PREVIOUS AEC-INFUSED FORMAL AND INFORMAL LEARNING

This sub-theme captures the components or strategies that RPs indicated impacted their AEC knowledge in one way or the other. These included components that impacted AEC knowledge prior to interacting with the fAEC-KLM. However, when probed further, it was noted that prior AEC knowledge mostly misinterpreted engineering in AEC to mean robotics and coding knowledge.

1A. ATTRIBUTING PRIOR AEC KNOWLEDGE GAIN TO INFORMAL LEARNING EXPERIENCES: Informal learning experiences in this case refers to summer camps, family member or role model influence on the prior AEC knowledge of participants before summer camp.

a) **Summer Camps:** RP mentioned gaining prior knowledge of AEC from previously attended STEM summer camps that mostly consist of robotics, coding, and Legos.
b) **Family member or Role model:** RP mentioned family influenced awareness about AEC through research and guidance.
c) **Personal experiences or research**: RP attributed AEC knowledge to their personal skills e.g., problem solving, math skills, creativity, and like for building things.

1B. ATTRIBUTING PRIOR AEC KNOWLEDGE GAIN TO FORMAL LEARNING EXPERIENCES:

Formal learning experiences in this case refers to regular school curriculum tailored classes.

a) **School Classes:** RP attributed AEC knowledge to school classes taken where they were either taught the concept or worked on a related project.

1C. NAVIGATING GENDERED PEEER INTERACTIONS

a) **Being underestimated by male peers:** RP mentioned being outnumbered by males in a classroom. And being undermined by males.
b) **Proving self because of male peers:** RP mentioned being outnumbered by males in a classroom. And being undermined by males.

SUB-THEME 2 – ATTRIBUTING POST-INTERVENTION AEC KNOWLEDGE GAIN TO fAEC-KLM

2A. SELF-ASSESSING IMPACT OF FAEC-KLM MODEL ON AEC KNOWLEDGE GAIN

This sub-theme captures participants' self-assessments of AEC knowledge gain using a 5-point Likert scale after interacting with the fAEC-KLM and components impacting these assessments.

1. **Increase in AEC knowledge rankings:** RP ranked knowledge higher in the post-interview compared to the ranking provided in the pre-interview.
   a) **Mid to High Rankings:** RP ranked AEC knowledge a 3 (mid) in the pre-interview but ranked a 4 or 5 (high) in the post-interview.
   b) **Low to Mid Rankings:** RP ranked AEC knowledge a 2 (low) in the pre-interview but ranked a 3 (mid) in the post-interview.
2. **Maintaining AEC knowledge rankings:** RP maintained the same ranking for both pre- and post-interviews.
3. **Decrease in AEC knowledge rankings:** RP ranked knowledge lower in the post-interview compared to the ranking provided in the pre-interview.
   a) **High to Mid Rankings:** RP ranked AEC knowledge a 5 (high) in the pre-interview but ranked a 3 (mid) in the post-interview.

2B. ATTRIBUTING POST INTERVENTION AEC KNOWLEDGE GAIN TO EFFECTIVE INTERACTIONS WITHIN THE fAEC-KLM:

Participants explained fAEC-KLM components that contributed to knowledge gain. Participants were asked a question in 11c to discuss how the effective components of the fAEC-KLM contributed to increasing knowledge needed to make AEC career decisions.

a) **Bridge design and construction Interactions:** RP mentioned kinesthetic activities like bridge design and or bridge construction as the effective components that increased their AEC knowledge.
b) **AEC Lecture Interactions:** RP mentioned AEC lectures, which comprised of sub lectures on the underrepresentation of African American women in AEC, AEC salary benefits, bridges, and mathematical calculations for bridges as the effective components responsible for increasing their AEC knowledge.
c) **Peer Interactions:** RP mentioned interaction with peers as the effective component for increasing their AEC knowledge.
d) **Coach Interactions:** RP mentioned interaction with coaches as the effective component for increasing their AEC knowledge.

e) **Gendered interactions:** Participants mentioned developing a career-related independence and understanding the need to not rely on the male gender to build things.
f) **Bridge Lecture Interactions:** Participants mentioned lectures on bridge design and construction as the effective component for increasing their AEC knowledge.

Appendix D.2: AEC Self-efficacy Codebook

THEME: fAEC-KLM IMPACTS AEC SELF-EFFICACY OF AFRICAN AMERICAN MIDDLE SCHOOL GIRLS

SUB-THEME 1 – ATTRIBUTING PRE-INTERVENTION AEC SELF-EFFICACY TO INFORMAL, FORMAL, OR SELF-EXPRESSED LEARNING EXPERIENCES

This sub-theme captures the experiences RPs indicated impacted their AEC self-efficacy in one way or the other. These included experiences that happened prior to fAEC-KLM intervention.

1A. ATTRIBUTING PRIOR AEC SELF-EFFICACY TO INFORMAL LEARNING EXPERIENCES: RPs expressed prior informal learning experiences such as summer camps and family members in AEC influencing AEC self-efficacy before fAEC-KLM intervention.

a) **Out-of-School-Time (OST) Educational Programs**: RP mentioned gaining prior AEC self-efficacy from previously attended STEM summer camps.
b) **Familial Social Support Network**: RP mentioned gaining prior AEC self-efficacy from watching a family member who is an AEC professional.

1B. ATTRIBUTING PRIOR AEC SELF-EFFICACY TO FORMAL LEARNING EXPERIENCES: RPs expressed prior formal learning experiences such as school classes influencing AEC self-efficacy before fAEC-KLM intervention.

a) **Deficient Mathematical Pedagogy**: RP mentioned liking math but not having adequate math education thereby reducing her AEC self-efficacy.
b) **Pre-Collegiate Engineering Education**: RP mentioned attending pre-college engineering classes in middle school helped boost AEC self-efficacy.

1C. ATTRIBUTING PRIOR AEC SELF-EFFICACY TO SELF-EXPRESSED LEARNING EXPERIENCES: RPs mentioned personal experiences that impacted their AEC self-efficacy prior to fAEC-KLM intervention.

a) **Ability to Succeed**: RP expressed determination to succeed in anything she set her mind to do as reason for having AEC self-efficacy prior to fAEC-KLM intervention.
b) **Kinesthetic Learning**: RP mentioned interest in hands-on and experiential learning as impactors for AEC self-efficacy prior to fAEC-KLM intervention.
c) **Lack of General AEC Interest**: RP expressed not having any interest in AEC as an impactor for AEC self-efficacy
d) **Self-belief**: RP expressed belief that she can do anything she puts her mind to do as AEC self-efficacy impactor.
e) **Self-esteem**: RP expressed the presence or absence of self-confidence in her abilities as an AEC self-efficacy impactor.

SUB-THEME 2 – ATTRIBUTING POST-INTERVENTION AEC SELF-EFFICACY TO FAEC-KLM

This sub-theme captures self-assessed levels of AEC of participants and the impactors of AEC self-efficacy gain, loss, or maintenance. These include comparison of pre- and post-rankings post fAEC-KLM intervention experiences.

2A. SELF-ASSESSING IMPACT OF FAEC-KLM ON AEC SELF-EFFICACY GAIN: RPs self-assessed their AEC self-efficacy before and after fAEC-KLM intervention.

a) **Increased AEC self-efficacy (Mid to High):** RPs ranked AEC self-efficacy mid (3) in pre-interview and high (4 or 5) in post-interview.

b) Maintained AEC self-efficacy:

i) **Low to Low**: RP ranked AEC self-efficacy low (1 or 2) in both pre- and post-interviews.

ii) **High to High:** RP ranked AEC self-efficacy high (4 or 5) in both pre- and post-interviews.

2B. **ATTRIBUTING POST-INTERVETION AEC SELF-EFFICACY GAIN TO EFFECTIVE INTERACTIONS WITHIN THE FAEC-KLM**

a) **Successful African American AEC Female Professional**: RP expressed leaning about African American AEC female pace setters and successful professionals as AEC self-efficacy impactor.
b) **Kinesthetic Learning**: RP expressed hands-on and experiential learning as AEC self-efficacy impactor.
c) **Self-belief**: RP expressed believing in self-abilities as self-efficacy impactor.
d) **AEC Knowledge Gain**: RP expressed learning more about AEC roles and responsibilities and other AEC concepts as self-efficacy impactor.
e) **Underrepresentation of African American women**: RP expressed the inadequate representation of African American women in AEC careers as self-efficacy impactor.
f) **Gender Impactors**: RP expressed being a female interested in AEC as self-efficacy impactor.
g) **Peer Interactions**: RP expressed interaction with other African American middle school girls during the summer camp as self-efficacy impactor.
h) **Lack of General AEC Interest:** RP expressed the lack of interest in AEC careers as self-efficacy impactor.

Appendix D.3: AEC Outcome Expectations Codebook

THEME: FAEC-KLM IMPACTS AEC OUTCOME EXPECTATIONS IN AFRICAN AMERICAN MIDDLE-SCHOOL GIRLS

SUB-THEME 1 – HIGHLIGHTING PRE-INTERVENTION OUTCOME EXPECTATIONS

This sub-theme captures the AEC benefits RPs consider as relevant to them even before interacting with the fAEC-KLM. They look forward to experiencing these benefits and explain how these benefits attracted them towards AEC careers.

1A. PRESENTING AWARENESS OF AEC OUTCOME EXPECTATIONS: RPs expressed what they believe are the benefits of AEC careers even before fAEC-KLM intervention.

- **d) Attributing to Career Opportunities:** RP mentioned the career opportunities AEC provides and how cool it will be to actually be an AEC professional.
- **e) Attributing to Career Satisfaction:** RP mentioned being an AEC professional as something to enjoy and appreciate.
- **f) Attributing to Cognitive Benefits:** RP attributed AEC outcome expectations to knowledge of math and mental abilities.
- **g) Attributing to Kinesthetic and Experiential Learning:** RP mentioned opportunities to build and decorate things as the main outcome expectations of AEC careers.
- **h) Attributing to Salary Benefits:** RP mentioned how well AEC professionals are paid as an outcome expectation.
- **i) Attributing to Teamwork:** RP mentioned working with others and sharing ideas as an outcome expectation.

1B. LACKING PERCEPTIONS ON OUTCOME EXPECTATIONS: RP had no idea what to expect from being an AEC professional so had no outcome expectation to mention.

- **b) Lacking Pre-Intervention Outcome Expectations:** RP has no awareness of the benefits of AEC careers and does not what to expect from being an AEC professional.

SUB-THEME 2 – HIGHLIGHTING POST-INTERVENTION OUTCOME EXPECTATIONS: This sub-theme captures RPs the increased awareness of the benefits of AEC and the experiences they look forward to, should they become AEC professionals.

2A. PRESENTING MORE DEVELOPED AWARENESS OF POSITIVE AEC OUTCOME EXPECTATIONS: RPs mentioned the positive experiences they look forward to, as AEC professionals.

- c) **Attaining More Knowledge:** RP ranked knowledge higher in the post-interview compared to the ranking provided in the pre-interview.
- d) **Attaining Respect:** RP ranked AEC knowledge a 3 (mid) in the pre-interview but ranked a 4 or 5 (high) in the post-interview.

e) **Attributing to Salary Benefits:** RP ranked AEC knowledge a 2 (low) in the pre-interview but ranked a 3 (mid) in the post-interview.
f) **Attributing to Self-Attributes:**
g) **Attributing to Sense of Belonging:**
h) **Benefiting from Teamwork:**
i) **Providing Resources for Community:**

2B. HIGHLIGHTING NEGATIVE POST-INTERVENTION OUTCOME EXPECTATIONS: RP mentioned experiences they are aware of that they are not looking forward to which influences their decisions to not be AEC professionals.

a) Expressing Detached Perceptions of Outcome Expectations:

2C. SELF-ASSESSING AEC OUTCOME EXPECTATIONS: RPs self-ranked AEC outcome expectations on a ranking scale of 1 (as lowest) to 5 (as highest) pre- and post-intervention of fAEC-KLM.

g) Increased Outcome Expectations: RP ranked AEC outcome expectations higher post-intervention.
h) Lowered Outcome Expectations: RP ranked AEC outcome expectations lower post-intervention.
i) Maintained Outcome Expectations: RP ranked AEC outcome expectations the same pre- and post-intervention.

Appendix D.4: AEC Interest Codebook

THEME: fAEC-KLM COMPONENTS INCREASE AEC CAREER INTEREST

SUB-THEME 1: ATTRIBUTING TO GAIN IN AEC KNOWLEDGE

This sub-theme captured important learning experiences and components that impacted the interests of Research participants (RPs) by increasing what they know about AEC. This sub-theme is comprised of three focused codes and their related open codes where possible as described below:

1. **Attributing to Knowledge Gain on AEC Technical Experiences:** This highlights knowledge gain on AEC concepts and practices through lectures and analytical experiences.
    a) **Gaining Knowledge on Bridge Design/Construction:** RP expressed the impact the lectures on the types of bridges, bridge designs, and bridge construction had on their AEC knowledge.
    b) **Gaining Knowledge on AEC Math Calculations:** RP expressed the knowledge they gained from the analytical part of the lectures where they had to use math abilities in calculations.
2. **Attributing to Knowledge Gain on Outcome Expectations:** This highlights the learning experiences RPs received on the benefits of being an AEC professional.
    a) **Gaining Knowledge on AEC Benefits and Salary:** RP expressed the impact the lecture on AEC roles, responsibilities, and salary had on their AEC career interest.
3. **Attributing to Knowledge Gain on AEC Intersectionality:** RPs mentioned the learning experiences they received on the importance of gender and racial diversity in AEC.
    a) **Gaining Knowledge on AEC Female Challenges:** RPs expressed the impact hearing stories of how female AEC undergraduate students and professionals faced challenges and navigated through them, had on their AEC career interest.
    b) **Gaining Knowledge on AEC African American Female Underrepresentation:** RPs highlighted the impact knowing about the lack of gender and racial diversity in AEC through the documentaries shared, had on their career interest.

SUB-THEME 2: ATTIBUTING TO GAIN IN SENSE OF BELONGING

This sub-theme captured important learning experiences and components of the fAEC-KLM that made them feel like they belong in AEC and impacted their career interests. This sub-theme is comprised of two focused codes and their related open codes where possible as described below:

1. **Attributing to Peer Support and Fun:** This category highlights the feeling and impact interaction with peers had on RPs' perceptions of AEC careers.
    a) **Gaining Peer Support and Interaction:** RP expressed how interacting and sharing ideas with other African American middle school girls made them feel and the impact it had on their AEC career interests.

b) **Gaining Fun Experiences through AEC Careers:** RP expressed how fun experiences within the fAEC-KLM made them feel and impacted their AEC career interests.

2. **Attributing to Observing African American (AA) Female AEC Professionals:** This category highlights how RPs felt interacting with and observing African American female AEC undergraduate students and professionals and how it impacted AEC career interests.
   a) **Attributing to Success Stories of AA Female AEC Professionals:** RP expressed the feeling they got from listening to the success stories of AA females and how they paved the way, and how it impacted their AEC career interests.
   b) **Attributing to the Need to Reduce Underrepresentation of AA Female AEC Professionals:** RPs expressed how deeply they feel about the underrepresentation of AA females in AEC careers.

SUB-THEME 3: ATTRIBUTING TO GAIN IN SELF-EFFICACY

This sub-theme captured components and experiences that increased RPs' "I can do it" attitude within the fAEC-KLM. This sub-theme is comprised of three focused codes and their related open codes where possible as described below:

1. **Attributing to Self-efficacy from Creative Accomplishments:** This category highlights experiences within the fAEC-KLM where creative activities intensified self-efficacy in RPs.
   a) **Gaining self-efficacy from Designing:** RP expressed how their interest in design gave them the confidence to succeed at the fAEC-KLM bridge design project.
   b) **Gaining self-efficacy from Creating** RP expressed how their interest in creative tasks, gave them the confidence to succeed at the fAEC-KLM bridge construction project.
   c) **Gaining self-efficacy from Assembling:** RP expressed how their interest in putting together gave them the confidence to succeed at the fAEC-KLM bridge design project.
2. **Attributing to Self-efficacy from Analytical Accomplishments:** This category highlights experiences within the fAEC-KLM where analytical activities intensified self-efficacy in RPs.
   a) **Gaining Self-efficacy from Math Abilities:** RP expressed how their math abilities and skills gave them confidence to succeed at the math calculations within the fAEC-KLM.
   b) **Gaining Self-efficacy from Problem-solving Abilities:** RP expressed how their problem-solving skills gave them confidence to succeed at the math calculations within the fAEC-KLM.

3. **Attributing to Self-efficacy from Hands-on Accomplishments:** This category highlights experiences within the fAEC-KLM where hands-on activities intensified self-efficacy in RPs.
   a) **Gaining Self-efficay from Bridge Designing:** RP expressed how kinesthetic activities gave them confidence to succeed at the math calculations within the fAEC-KLM.
   b) **Gaining Self-efficacy from Bridge Construction:** RP expressed how kinesthetic activities and project development gave them confidence to succeed at the math calculations within the fAEC-KLM.

PATTERN CODING ON INTEREST CATEGORIES

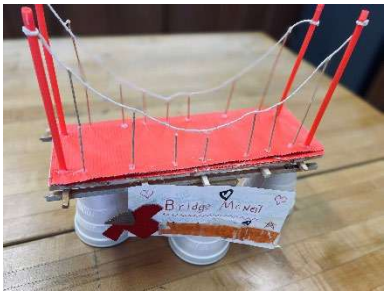
1. **Active Interest Category:**

a) Ranking AEC interest high (5)
b) Choosing AEC as first career choice
c) Exhibiting Creative skills as dominant career self-attribute
d) Prior exposure to Informal STEM learning

2. **Passive Interest Category:**
   a) Ranking AEC interest mid to high (3-4)
   b) Choosing AEC as second or third career choice
   c) Exhibiting Analytical skills as dominant career self-attribute
   d) Some have prior exposure to informal STEM learning
3. **Null Interest Category:**
   a) Ranking AEC interest low (1-2)
   b) Not choosing AEC as top career choice
   c) Exhibiting social skills as dominant career self-attribute
   d) No prior exposure to informal STEM learning

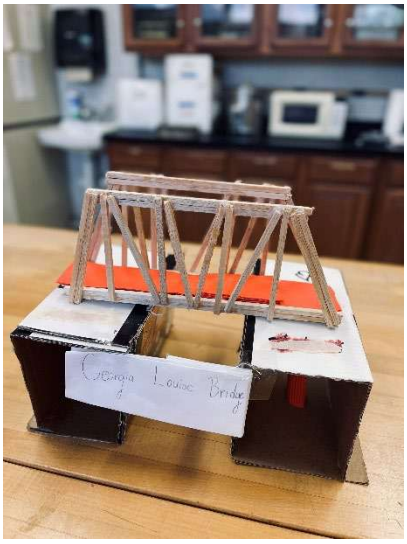
Appendix E: Images of Completed Bridge Projects by Participants.

Appendix E.1

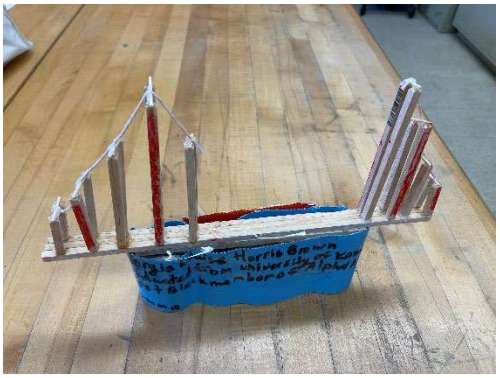


Appendix E.2

Appendix E.3



Appendix E.4



Appendix E.5