Chapter 8
Black Girls STEAMing Through Dance:
Inspiring STEAM Literacies, STEAM Identities, and Positive Self-Concept

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ABSTRACT

Black Girls STEAMing through Dance (BGSD) leverages a transdisciplinary partnership among four Black women professors in urban education, dance, industrial/product design, and computing to engage Black girls in a STEAM-infused program to inspire STEAM literacies, STEAM identities, and positive self-concept. BGSD is in its third year of existence and operates across several contexts, including an after-school program for 7- to 12-year-old Black girls, a co-curricular mini course program for 5th and 6th grade girls, and a professional development course for

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teachers. This chapter highlights how the program was developed and how the use of dance to integrate STEAM is a promising platform to encourage engaged STEAM participation amongst underrepresented Black girls.

INTRODUCTION

Black women and girls are severely underrepresented in Science, Technology, Engineering and Mathematics (STEM) fields across both educational and career continuums (Marra, Rogers, Shen, & Bogue 2009; Pinkard, Erete, Martin, & McKinney de Royston, 2017; Towns, 2010). Their access to STEM pipeline opportunities which could lead them on a path towards future STEM majors and career trajectories lags significantly behind their White female and male counterparts (Farinde & Lewis, 2012). Meanwhile, the United States has an urgent need for a highly skilled and innovative STEM workforce and STEM leaders in order to stay competitive in a global marketplace (Diekman, Steinberg, Brown, Belanger, & Clark, 2017). Nearly 25% of all STEM fields are comprised of women (Simon, Wagner, & Killion, 2017), and the numbers are even more alarming for Black women. According to the National Science Foundation's National Center for Science and Engineering Statistics (2019), Black women graduates represent 4.5% of the biological sciences, 2.2% of computer science, 2.5% of physical sciences, 2.1% of mathematics and statistics, and 1.0% of engineering conferred degrees. Although there have been gains in access to STEM education earlier in students' schooling experiences (Lindeman, Jabot, & Berkley, 2014; Murray, 2019), there remains grave inequities across socio-economic, racial/ethnic and gender lines, particularly as it relates to Black girls (Ireland, et al., 2018; King, 2017; King & Pringle, 2018; Marra, et al., 2009; Young, Tolliver, Young, & Ford, 2017). Some scholars have even deemed this lack of access to STEM opportunities at the early onset and throughout Black girls' education, a civil rights issue (Espinosa, 2011; Mensah, & Jackson, 2018; Tate, 2001), and there has been little progress toward comprehensively and systematically eradicating these gaps and challenges (Ireland, et al.,2018).

STEM education access in formal and informal learning spaces is limited for Black girls as a whole and often representative of compounding socio-political issues of racism, sexism, and generational poverty which keep Black girls pushed out of transformative learning experiences (Morris, 2015). Even if STEM education is available, these opportunities are often disconnected from the historical, cultural, gendered, and daily lives of Black girls, and the cultivation of a STEM identity frequently lacks intersectional, socio-cultural relevance for them (Charleston, Adserias, Lang, & Jackson, 2014; Ireland, et al., 2018). According to Brown, Mangram, Sun, Cross, and Raab (2017), "there are numerous ways to be African

American, selecting an identity that allows you to integrate being Black and being scientific can be empowering" (p. 179). However, the neoliberal agendas of schooling in urban education (Lipman, 2013) create additional hurdles to bridging these gaps for Black girls' culturally congruent STEM identity formation.

While these lingering challenges have been well articulated and substantiated in the extant literature, there is however, a burgeoning body of scholarship that is examining ways in which to best engage Black girls in STEM education, in a format they can appreciate and in a way that leverages their funds of knowledge and cultural wealth (Amanti, González, & Moll, 2005; Khalifa, Gooden, & Davis, 2016; Yosso, 2005). Several asset-based pedagogies and programs are being employed to cultivate Black girls STEM learning throughout their PK-12 education, so that they can envision the possibilities of pursuing STEM majors and careers in the future (Morales-Chicas, Castillo, Bernal, Ramos, & Guzman, 2019; Scott, Sheridan, & Clark, 2015). Particularly, several informal learning programs such as Digital Youth Divas (Pinkard, et al., 2017), Black Girls Dive: STREAMS Program (Black Girls Dive Foundation, 2019), Black Girls CODE (Scott & White, 2013), and DanceExcel (Champion, 2018) are integrating various elements of STEM, while also utilizing concepts of project based learning and culturally relevant and sustaining pedagogies (Ladson-Billings, 1995; Paris, 2012). Such approaches have demonstrated Black girls increased engagement and motivation in STEM (Daily, et al., 2014; Parmar, et al., 2016; Pinkard, 2005), and there is a growing interest in the intersections of Art and STEM, which has resulted in the evolution to Science, Technology, Engineering, Art, and Mathematics (STEAM) education.

STEAM has been noted to support girls' ability to make connections across disciplines through creative processes, innovation, and problem solving (Lam, 2013; Liao, Motter, & Patton, 2016). Dance as a platform to integrate STEM is an early candidate to encourage STEAM engagement, particularly for Black girls, for dance has been and continues to be woven into the fabric of African American culture (Malone, 1996; Stovall, 2015). Considering that dance touches practically every aspect of Black life, unfortunately it (and the arts in general) is often absent from schools that serve majority Black students in urban environments. According to Parsad and Spiegelman (2012), there is a downward trend in access to arts education and dance instruction specifically. Particularly, they indicate that 95% percent of elementary school and 77% of secondary school children that attend schools where 75% or more of students receive free and reduced lunch do not have access to dance instruction. Bearing in mind, the grave disparities in STEM and Arts access and education, ***Black Girls STEAMing Through Dance*** (BGSD) was created to disrupt pervasive gaps in the underrepresentation of Black girls in STEM and STEAM, and to inspire a new generation of Black girls with strong positive self- concept and crystalizing STEAM identities.

BLACK GIRLS STEAMING THROUGH DANCE

BGSD launched in the Fall of 2017 and operates across several contexts. First, BGSD serves as an after-school program for 7-12 year old Black girls at the Dornsife Center for Neighborhood Partnerships in West Philadelphia (**BGSD Dornsife**). BGSD is also offered as a co-curricular mini course program for 5th and 6th grade girls at the Science Leadership Academy Middle School (**BGSD SLAMS**), as well as a professional development course for teachers (**BGSD Teach**). Our program is led by four African American women professors, an African American woman graduate assistant, and three African American women undergraduate assistants. BGSD represents a transdisciplinary partnership amongst our various fields in urban education, dance, product/industrial design, and computing.

BGSD Dornsife engages girls in a dance class consisting of jazz, modern, ballet, and Hip Hop taught by Val and our undergraduate assistants, while integrating various elements of STEAM taught by Raja, Michelle, and our graduate research assistant Monique. BGSD follows the Drexel University academic calendar divided into three eight-week sessions across the fall, winter, and spring quarters. Each week, girls rotate between the *The Coding Lab* and *The Design/Making Lab*. In *The Coding Lab*, they learn to code and integrate virtual reality (VR). In *The Making Lab*, they learn about design and circuits and create the wearable technologies for their dance costumes. Our weekly activities draw inspiration from and bring inspiration to their dance instruction, where girls also "make" with their bodies and design their own choreography. In **BGSD SLAMS**, the students participate in an 8-week, 80-minute weekly program that combines instruction in choreography, design, and coding through the use of the Chibitronics Make-code application and a blend of Technokio and Chibitronics hardware. The girls engage in choreographing group dance sequences and design illuminated costumes for a final showcase music video. **BGSD Teach** supports 2nd-8th grade teachers from the West Philadelphia Promise Neighborhood. During the hands-on, day-long workshop, teachers participate in standards driven STEAM activities that connect movement, coding, and design. At the conclusion of the workshop, teachers plan lessons to take back to their classrooms, with support from the authors throughout the school year.

Ultimately BGSD is purposed to create an ecology of STEAM experiences to inspire Black girls' STEAM literacies, STEAM identities (wherein the participants internalize that they are dancers, scientists, engineers, artists, designers, etc.), and the formation of positive self-concept. Another objective of BGSD is to support STEAM teachers' development of self-efficacy, cultural competence, and culturally sustaining pedagogies (McCarthy-Brown, 2017; Paris, 2012). Throughout this chapter, the authors will highlight BGSD and share how our program's use of dance to integrate STEAM is a promising platform to encourage engaged STEAM

Figure 1. Chart of BGSD energy unit plan.

DISCIPLINE	DEFINITIONS	CLASS THEME	CLASS EXPERIENCE	LESSONS LEARNED
DANCE	Energy is the potential for force. Energy is known as a core element of dance.	Explore active and passive energy	Everyone in the class will stand spread out across the performance space and when a solo dancer makes a sharp shape, the dancers closest to the soloist will respond by changing the direction they are facing, level (high, mid, low) and make a shape with their body. Each dancer will respond with the new shape once the dancers next to them have made a new shape.	This experience will: 1. Emphasize the difference between passive and active energy and how both feel in the body. 2. Create a ripple effect within the group, visually representing how energy passes from one point to another. 3. Allow the use of multiple bodies to emphasize how energy can be amplified.
DESIGN and MAKING	Energy is how power is transmitted through materials from a power source like a battery to an output like a light.	Demonstrate power transmission through simple circuits using batteries, conductive materials, and LED lights	Everyone in class will review basic circuit diagrams and create a sample circuit using an LED conductive tape and a battery and then they will create a light up bracelet.	Through this experience students will: 1. Understand the difference between positive and negative terminals on a power sources. 2. Understand how traces (i.e. conductive thread, ribbon, wires) can be made between a battery and an output source (i.e. LED light). 3.Students will understand how to measure materials to fit the body and how to apply flexible electronic materials to e-textiles.
CODING	Energy can be modeled and demonstrated in programming characters	Explore coding movements and concepts	Everyone in class will begin by creating their characters to represent themselves and/or an idea. They will then enable that character to move	This experience will 1. Demonstrate how characters can move and express energy 2. Use paired programming to assist girls with understanding and completion of activities

participation amongst underrepresented Black girls (Daily, et al., 2014, Pinkard, et al., 2017). Furthermore, the authors will demonstrate its promises for the field and the emerging body of literature about the transformative integration of the arts in STEM learning for historically marginalized Black girls. Figure 1 show a chart of a BGSD energy unit plan.

DANCE

Why We STEAM through DANCE

Dance is the foundational element of BGSD and it serves as the conduit for developing STEAM literacies, STEAM identities, and positive self-concept because we use the physical body as the vessel for learning and creative expression. Black and Brown

bodies, which have been historically marginalized and classified as "minorities" in the U.S., (when in fact they have been minoritized; Harper, 2012) are significantly underrepresented in mainstream STEM and STEAM opportunities. Yet, in BGSD all bodies regardless of skin tone or shape are celebrated, honored, and are a significant part of reclaiming a positive sense of self for Black girls.

How We STEAM Through Dance

Over the last three years, the model has evolved based on the structure of our partner programs. BGSD grew out of an existing dance program at the Dornsife Center for Neighborhood Partnerships at Drexel University in Philadelphia, which was led by then Dance Program Director and co-author Val Ifill. The afterschool and Saturday dance program at the Dornsife Center was robust, and provided community dance classes for children ages 4 to 18 and adults 19 to mid-90s. After three years of running a successful *Dance at Dornsife* program, Val began to look for ways to expand programming for highly engaged participants. She joined forces with Ayana, Raja, and Michelle, and BGSD was born out of a *Learning Innovations Seed Grant* from the Drexel University ExCITe Center.

The first year of the program, BGSD partnered with a concert dance class featuring movement from modern, jazz and ballet dance. The second year we made a change by connecting to hip-hop curriculum. The students took a one-hour dance class followed by a one-hour design/making or computing lab focused on design using wearable technology or coding. Throughout each session, students participated in journaling and reflective activities about their interests and experiences in the program. We also began BGSD SLAMS in year two. Now in our third year, BGSD Dornsife has implemented a few changes based on our assessment of the first two years, and growth of the program. The first major change is that dance and lab time are integrated together once a week for an hour vs. the two hours in previous years, combining dance, design and computing in one cohesive experience. In this new model, the girls are able to make connections between all three subject areas at the same time.

Dance as an Art Form

In BGSD, dance both stands on its own as an artform in addition to being utilized to support and translate other disciplines. Performance and choreography are emphasized in our program. Students invest in improving dance technique in addition to learning the elements of dance-making. Collaborative dance-making amongst the students, supported by our team of faculty, graduate student, and undergraduate students, is a

key component of our work. Allowing the dancers to have agency over their bodies and make choices based on how they want to interact with the design and code elements, deepens their kinesthetic, cognitive, and psychological-social learning.

Dance as Reflection

Dance is used as a tool to reflect and respond to learning experiences in coding and design, as well as, a way for the girls to share what they've learned about the art of Dance-making as a form of self-expression. In education, verbal and written communication often hold high value. Through our program, students have the opportunity to engage in nonverbal reflection which could be helpful for many learners including kinesthetic learners and visual-spatial learners, described by Howard Gardner's Multiple Intelligences Theory (Gardner, 1983). An example of dance as reflection is when students have experience in one of the design or code labs or when they view choreography, they are asked to create a movement gesture that summarizes how they feel in response to what they have just seen. This mode of processing, allows students who have a difficult time using words to express feelings or ideas, additional options to show an understanding of content. The teacher can gather information about the girls' responses by looking at posture, shapes, dynamics and focus.

Dance as a Form of Presentation

At BGSD Dornsife, our 9-month program focuses on technique and skill-building for the first three months, creative process for the next three months and the final three months are spent building a culminating experience. Since dance is a performing art, it is the perfect form to feature the learning that has taken place throughout the year. In BGSD Dornsife, for the first two years, the dancers, in partnership with their undergraduate student teachers, created a three-minute dance involving wearable technology that responded to their choreography. The choregraphed dance was performed on a proscenium stage in the Dance at the Dornsife Center end-of-year concert for family and friends. For the third year of the program, students will showcase the process as well as the product on their learning journeys. A gallery space will be created to showcase mini projects and site-specific dances will be performed inspired by what they learned using the costume pieces they design. At BGSD SLAMS, the girls create a final showcase dance on film in the dark that highlights their co-constructed choreography and the designs of their illuminated costumes, which they have created throughout the program. Figure 2 and Figure 3 show BGSD SLAMS images.

Figure 2. BGSD Dornsife Performance Dress Rehearsal

DESIGN AND MAKING

Why We STEAM Through Dance Using Design and E-textiles

Through Dance and Design, we want students to understand the relationship between our bodies and what we wear on them, and to ask the question, "*How might we celebrate, sense, or show how our bodies interact with space and over time?"* By connecting what we design to coded electronic components, we can both augment dance performances and apply computer science (CS) skills to physical objects. Design is integral to our STEAM curriculum because Design influences all aspects of life—from the homes we live in, the shoes we wear, the chairs we sit in, the advertisements around us, and the cell phones we use to communicate. Designers not only dictate the way these things look, but they also have the power to inform the way these things work, how they are made, what they are made from, and how they help us with everyday tasks. Without understanding the power of design to shape our everyday lives, students are merely the users of objects and tools. Once students gain an understanding that there are people behind the decisions that shape the things we own, use, and experience, they begin to understand that design can

Figure 3. BGSD Dornsife Performance

change lives, and they can imagine themselves as future designers who can use their STEAM knowledge and skills to change the world. An emerging field in Industrial Design is wearable technology. Largely, this is seen in health/fitness monitors, light up sneakers, smart watches, hearing aids, and augmented reality headsets. Integral to successful wearable products is an understanding of the body, lifestyles, and fashion. These wearable devices also require coding and wiring in order to work. So, we are using the overlap of Industrial Design, wearable technology, coding, and Dance to introduce our girls to the design process by making wearable electronics that are paired with embodied movement.

How We STEAM through Dance Using Design and E-textiles

By leading girls in creating e-textile based wearables, we're able to address skills and knowledge related to designing and making with textiles materials and sewable electronic components, controls, and sensors. Our primary output has been working with lights in the form of small LED (light emitting diode) stickers and sewable

sequins. At BGSD Dornsife, we divide the students by age, 7-9 and 10-12. The program is broken into two phases, one addresses skill-building and the other is an introduction to the process. During this skill-building portion, the students create simple accessories for the body and learn about electronic circuits. We cover concepts such as series and parallel circuits and closed and open switches. The students show evidence of understanding by prototyping the circuits using conductive tape, batteries, and LEDs. We also introduce the students to various control hardware and sensors including mechanical switches, velostat (a conductive pressure sensitive plastic sheet), light sensors, and tilt sensors. The culminating exercise for the skill-building portion is to make a light-up cuff using felt and LEDS and simple switches, and ultimately the girls design their own costumes. Figure 4, Figure 5, and Figure 6 show the costumes being designed.

Math is used as the students use measuring tapes to measure parts of the body. We review the differences between metric and imperial measurements and the girls have to include the unit of measurement on their notes for clarity. The students also use simple addition to plan for extra material so there is an allowance for applying the battery pack and securing the cuff to the body. They use these measurements to create paper templates to sketch out design ideas and plan the circuit before transferring the design plans to felt, applying conductive tape, LED stickers, and battery packs. Through this exercise, we introduce design brainstorming through sketching, iterative development, and testing.

The two groups work with slightly different sets of electronic hardware components. This is due to age ranges of the hardware kits, the level of challenge we want the students to experience, as well as the level of support in the classroom. For the younger group of girls (ages 7-9) we largely use adhesive-based conductive components including LED stickers and conductive tape. Our older girls are introduced to hand sewing and use both the tape and conductive thread along with sew-on LEDs. In order to create stronger connections to both Dance and CS, during the second phase, the students use their basic design development skills, materials understanding, and electronic knowledge to plan light-up designs that are tied to a specific dance movement or sequence. This presents an opportunity for the dancers to think about how their embodied movements can be connected to and augmented by the lights worn on the body in strategic locations. For instance, if a dance involves a lot of stomping, a student might put a light lower on the body near the feet and make use of a tilt sensor, while a more lyrical gesture of a hand moving along with music might suggest placing lights in proximity to the hand or as an extension of the arm. Whereas turning and twisting might mean that placing lights on a skirt to accentuate the material lifting away from the body as the dancer moves. Since both choreography and coding is composed of sequences and loops, the students can use

Figure 4. BGSD Dornsife Cuff Design

their computational understanding to control the lights as well by designing light sequences and looping patterns that align with both the music and choreography.

COMPUTING

Why We STEAM through Dance Using Computational Thinking and Coding

Coding and more specifically, computational thinking is an excellent candidate for forming a STEAM identity (Daily et al., 2015; Pinkard, 2005). While computing used to be a solo activity, it is now more focused on outcomes and co-constructing as a community of learners (Kafai, 2016). BGSD, being a transdisciplinary project

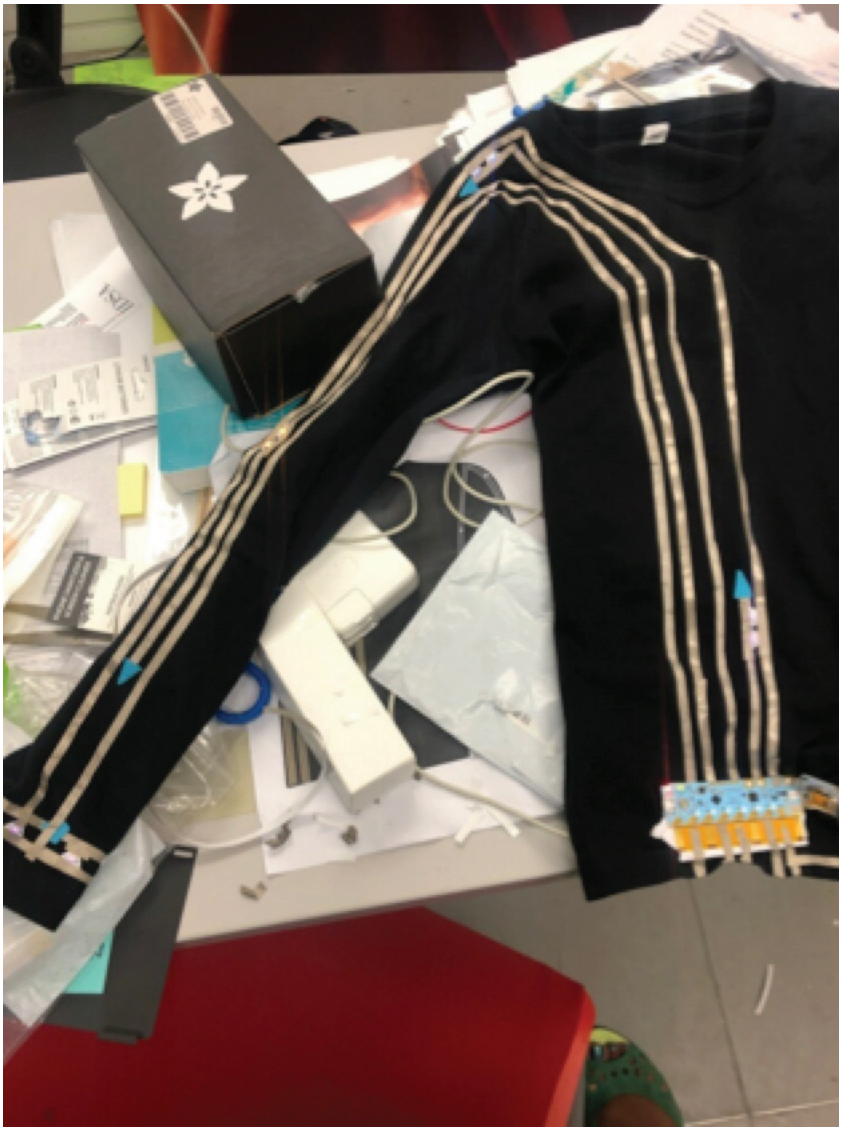
Figure 5. BGSD Dornsife Costume Design

between education, dance, design, and CS, allows for the girls to get direct instruction and interactive experience in coding as part of their making, and influenced by their dance.

How We STEAM through Dance Using Computational Thinking and Coding

In order to support the making and dance portion of the program, the goal of the coding content is to provide the students with the opportunity to create in technical terms. Ongoing connections are made between coding and dance and coding and

Figure 6. BGSD SLAMS Costume Design



design. First, between coding and dance, we use words and phrases that could demonstrate embodied movement. For design and coding, we identify coding aspects of design that allow the girls to activate their designs and make them interactive. When considering dancing, we looked at what codes would build on their knowledge. We frequently use three concepts– loops, conditional statements, and sequencing to demonstrate both dance and design. In our first year of BGSD

Figure 7. BGSD Coding Lab

Dornsife, the 10-12-year-old girls participated in the coding lab for three weeks, while the 7-9-year-old girls participated in the design/making lab. After that time elapsed, the groups switched. To manage the different age groups, it was decided that the younger girls would use scratch-base characters to demonstrate movements and actions. The older girls used the Tynker® platform with more mature looking characters that also used block coding to control their movements. In Figure 7 and Figure 8, the students are working in the coding lab.

The block coding platform allows for novice users to control characters without being able to write actual computer syntax (Kaplancali & Demirkol, 2017). Through the design and making components of the project, the girls participated in the application of the CS content. The CS component supported, and reinforced

Figure 8. BGSD Coding Lab

computational concepts observed in the dance and making. Specifically, students showed increased knowledge as they learned to correlate topics such as loops and conditional statements in coding language to their dance moves. So, if they did a dance that involved the repetition of a move, they were able to see that exemplified in the use of loops in the code they wrote. Advances to this work look to understand how the girls envision creating together as a group to produce desired outcomes. In addition, understanding is needed about how we continue to make the CS connections using actual programming syntax (e.g. Python, C++) rather than block coding (Weintrop, & Wilensky, 2015).

BGSD ON THE MOVE FORWARD

As the program enters its third year, we are constantly considering how to cater to the interests and strengths of each BGSD cohort. We do have several returning girls, but also many new ones, and most of our first weeks of lessons are spent building rapport and relationships with one another. We are also excited to launch BGSD Teach this spring. We are currently recruiting our first "class" of STEAM teachers to participate in our teacher workshop. We are also ever aware of the evolving nature of technology and the fields of industrial design and CS. As technology continuously develops, it is important for our students to be aware of current and future advancements. Therefore, virtual reality (VR) is being implemented into BGSD this year to introduce our girls to advanced technologies and to cultivate a STEAM identity in which they have agency over the technology. It must be noted that there are multiple definitions of virtual reality (VR), and for the purpose of BGSD, VR is defined as a computer-generated immersive environment that is viewed with a head-mounted display (Papanastasiou, Drigas, Skianis, Lytras, & Papanastasiou, 2018). When using VR devices in education, students are motivated and engaged in the topic they are learning (Chen, 2010). Furthermore, this technology also enables learners to transfer the information they learn from the virtual environment to reality with ease (Curcio, Dipace, & Norlund, 2016). In BGSD, VR provides an opportunity for the girls to utilize their newly gained skills in design and coding to construct a cohesive VR experience. The girls will use CoSpaces Edu, an online software, to design and code their VR environments. They will design their own dance characters in any setting they desire, such as outer space or a city. Once the characters are designed, students will then code their characters' movements and interactions. The addition of VR will also expand Math learnings. For example, in CoSpaces Edu, users only have the capability to enter the distance and time it takes for an object to move from one place to another. Therefore, as the girls begin to code their VR environments, they will learn how to calculate speed, which is distance divided by time. Using this software, the students will have the opportunity to apply their skills to create one cohesive environment that showcases their newly acquired knowledge.

In summary, ***Black Girls STEAMing through Dance*** continues to bridge the racial and gender disparities in STEM by incorporating the arts into STEM activities to develop and maintain their STEM interests. By integrating dance throughout all aspects of BGSD, dance serves as an artform and entry point to leverage the cultural wealth of Black girls. STEAM activities are scaffolded from learning to dance (Art), to making and designing costumes (Art), and lastly coding to enhance costumes and to create VR dance environments (CS, Technology, Engineering, Mathematics). BGSD is a model of transitioning from STEM to STEAM that leverages the cultural

wealth and daily lives of Black girls. BGSD is an unapologetically Black girl program for and implemented by Black girls, and as such, BGSD demonstrates that African American girls can develop positive STEAM identities and positive self-concept through the transdisciplinary nature (education, dance, design/making, CS) of BGSD.

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KEY TERMS AND DEFINITIONS

Block Coding: A method of visual programming that allows one to program without having to write syntax in the form of a specific programming language. It is often used as an introduction to coding to beginners.

Community Cultural Wealth: The various assets or capitals that are embedded in historically marginalized communities such as social capital and linguistic capital, yet they are often overlooked by schools and institutions.

Computational Thinking: The development of thought processes that reflect the steps that one would execute to instruct computers to perform tasks.

Culturally Sustaining Pedagogy: Fostering, centering, and sustaining the ways of knowing and being of historically marginalized students throughout their educational experiences.

E-Textiles: Textiles with electronic circuits (including a power source and output like a light) embedded in or applied to the textiles.

Embodied Learning: Involving the movement and the physical body in the process of learning.

Immersive Environments: Simulation that provides the user with a sense of physical presence.

Making: Freely exploring endless possibilities through creating, designing, experimenting and producing, supporting one's innovation, creativity, and freedom of expression.

Programming: The process of writing source code that instructs computers to perform tasks.

STEAM: Science, technology, engineering, arts, and mathematics.

Virtual Reality (VR): A computer-generated immersive environment that is viewed with a head-mounted display.