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ACTIVITIES AND PROGRAM MODEL

Empowering and Inspiring Young Girls a STEM at a Time: Using Place-Based Learning to Cultivate STEM Identities

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Black Girls Dive Foundation (BGDF) was established to empower and inspire young girls to explore their STEM (Science, Technology, Engineering and Mathematics) identities through aquatic-based STEM activities and ocean stewardship. BGDF's STREAMS program integrates aquatic-based recreation of SCUBA with scientific diving, ocean science, and stewardship. STREAMS explores ways to have broader reach and impact on STEM identity and STEM interest for individuals who are historically underserved and underrepresented in the sciences and provides research informed ways to close the divide and bring about equity.

Keywords: STEM programming; aquatic sciences; informal sciences; minorities; girls; placed-based learning; African-Americans

Introduction

For the past four years, Black Girls Dive Foundation (BGDF) has impacted over 245 young girls, either through participation in our STREAMS program or through community STEM outreach activities. BGDF was established to empower and inspire young girls to explore their STEM (Science, Technology, Engineering and Mathematics) identities through aquatic-based STEM activities and ocean stewardship, specifically through SCUBA and scientific diving. Black females in STEM, particularly in aquatic-based STEM career fields, are far and few, as is aquatic-based recreational exploration. Why? Because of Black culture and history. According to a collaborative study published by USA Swimming Foundation and the University of Memphis, approximately 70 percent of African Americans do not know how to swim (Irwin, 2010). Intergenerational fear, a symptom of past discrimination and segregation, has led to swimming never becoming a part of African-American recreational culture (Wiltse, 2009). In fact, the USA Swimming Foundation study shows that "if a parent does not know how to swim, there is only a 13 percent chance that a child in that household will learn how to swim."

If we could change the cultural narrative through outreach and opportunity, would more Black women be interested in aquatic-based STEM programs? Diversity strengthens scientific collaborations and ingenuity as seen in research on diverse groups outperforming individual problem solvers. Racial, ethnic, and socioeconomic diversity is more than a matter of equity. Diversity is the substance of social and economic vitality and global leadership. It is the synergistic leadership, and the collaborative contributions of women and men of various backgrounds, beliefs, and cultures, that will best advance solutions to global issues and challenges. A 2007 National Academies of Science report that focused on increasing underrepresented minorities in STEM fields showed that African Americans, Hispanics, and other minorities have comprised only 15 percent of science and engineering occupations population (Johnson and Okoro, 2016). Through the years this number has essentially remained the same. The proportion of underrepresented minorities in science and engineering would need to triple or quadruple to match their share of the overall United States population. (Johnson, Huggans, Siegfried, Braxton, 2016).

Creating and cultivating ocean stewards should start with our youth. This is important considering what we know about our climate and state of the ocean ecosystem. The ocean is coming under increasing threats from overfishing, pollution, climate change, habitat destruction, and many other problems. We must act to protect and conserve the ocean before it's too late. One way that we can help mitigate this problem is through education. Around the world, and particularly in the United States, awareness and public knowledge of the ocean is poor. There is very little ocean science being taught in K-12 classrooms. In underserved schools, even fewer students receive an adequate ocean education because there is little money to offer elective ocean science classes and to provide the necessary training and resources for their teachers (Cava et al. 2005).

A lack of ocean-literate people, "an understanding of the ocean's influence on you and your influence on the ocean," (Cava et al. 2005) could result in the public making uninformed decisions that could negatively impact the ocean. Studies show that, by enhancing public knowledge and awareness of the ocean, there will be an increased public support for ocean restoration efforts (Steel et al. 2005) and increased individual responsibility when it comes to choosing environmental decisions that help the ocean (Plankis & Marrero 2010). Youth are a crucial component in developing an ocean-literate society. A 2009 survey conducted by the Ocean Project revealed that "young people aged 12 to 17 know and care more about the ocean and environmental issues, and they are more willing to act than adults" (Ocean Project 2009, pg. 2). Additionally, the study showed that youth influence the opinions of adults, who in turn view their children as better informed on the topic of conservation issues. With such a lack of ocean science requirements in K-12 formal education, informal education programs such as our STREAMS program help to fill this knowledge gap.

Our work is motivated by five critical needs: (1) broaden participation of Black girls who engage in aquatic-science; (2) advance collaborative partnerships; (3) identify best practices for incorporating new media technologies into learning environments in a way that resonates with youth, including their interests, goals, and the ways they use technology in their everyday lives; (4) document and recognize informal STEM learning and connect it to formal education contexts; and (5) develop strategies for inspiring and tracking student progress towards the learning goals outlined in the *Next Generation Science Standards (NGSS).* We believe our work will ultimately advance the STEM education field by providing new theoretical insight into leveraging networked technologies to develop learners' STEM identities, recognize and connect youth's STEM learning experiences across contexts, and open up future educational and career opportunities for them.

Conceptual Framework of STREAMS program

STREAMS (**S**cience, **T**echnology, **R**obotics, **E**ngineering, the **A**rts, **M**athematics, **S**CUBA/Scientific Diving) leverages existing collaborative partnerships as a broadening participation strategy. We recognize that more cross-sector collaborations need to occur to ensure the success of reaching underserved and historically underrepresented girls in STEM. Examples of partnerships could include institutions of higher education, non-profit science-based organizations, community-based organizations, e-learning partners, and dive industry partners. These entities' expertise and experience could provide a robust perspective. Bridging contexts allows the learner to see the relevance of their own learning and make a connection across contexts, and educators capture opportunities that link their own formal learning goals to the experiences of learners in informal settings. Our program is conceptually grounded in STEM identity work (Carlone and Johnson, 2007) and practice-linked identities.

Identity and Agency in STEM learning

Historically, scientists have been stereotyped as white men in lab coats. It is easy to see why a young Black or Brown girl might find it difficult to imagine herself as a scientist. Studies have shown that a failure to identify with the dominant images of scientists has been linked with lower interest and pursuit of learning in math and science among middle school girls (Bartonet al. 2012; Hughes, 2012) and ultimately affects career choice (Hazari, Sonnert, Sadler, & Shanahan, 2010). It is for this reason that STREAMS exists. It provides an opportunity for young Black and Brown girls to participate in a STEM program and see others who come from the same cultural background. It is important to take into consideration one's gender, and racial and ethnic identities. This is what makes up one's "science identity," or culmination of a scientist's competence, performance, and recognition by others. Carlone and Johnson (2007) developed this model of science identity to view Black women's experiences in science. This model is based on the assumption that one's gender, racial, and ethnic identities affect one's science identity; which is a culmination of a person's competence, and performance and recognition by meaningful others as a science person. In the former, recognition brings about reputation, and reputation is a marker of being perceived or recognized as an expert.

Moreover, practice-linked identities are essential in forming identities within socially and culturally constructed contexts as it serves as a source of personal agency (Nasir and Hand, 2008). Young girls are able to make a connection between themselves and STEM. Serving as a source of personal agency, these young ladies engage in practice-linked identities and take on, construct, and embrace these practiced-linked identities that are linked to participation in particular social and cultural practices, in this instance STEM learning. There is a complex interplay between structure and agency, and by deepening learners' engagement in an activity, practice-linked identities ultimately support STEM learning.

Through informed research and best practices, and the assistance of a robust network of industry and community partners, BGDF has developed the STREAMS program that positions young Black and Brown girls and women to learn about the aquatic sciences and ocean stewardship. Girls learn to SCUBA dive and train in scientific diving practices and learn about marine and ocean sciences. They also explore oceanographic engineering by designing and building different types of underwater remotely operated vehicles with various recording mechanisms to explore diverse marine ecosystems. Programming provides mentorship, hands-on and minds-on engagement in science, and a social network for youth participants to practice their own agency in an environment familiar in culture and like-mindedness/interest. This latter part is key as research has shown that oftentimes girls and young women feel unheard. Referred to as "losing their voice," this phenomenon manifests itself in even the most audacious girls who become more cautious about speaking out and less likely to assert themselves.

Black girls interested in science and engaging in aquatic activities such as SCUBA diving and who learn about, discuss, and practice habits of mind for ocean stewardship may feel even more alienated in their general peer group. Research has shown that African Americans' participation in activities involving nature and outdoors is significantly lower than the dominant culture (Goodrid, 2018). For this reason, BGDF creates social spaces and opportunities for the girls in the program to establish camaraderie. BGDF explores ways to have broader reach and impact on STEM identity and STEM interest for individuals who are historically underserved and underrepresented in the sciences and provides research informed ways to close the divide and bring about equity. It is our position that in addition to mentorship, youth need culturally relevant curriculum they can relate to and opportunities to engage in habits of mind of a scientist with other scientists who are relatable. They also benefit from networked technology, such as digital badging, and expanded access to bring about equity and create a bridge across learning and career contexts. Moreover, using a place-based learning model enables deeper, more meaningful learning. There is power in place, and leveraging that power creates authentic and organic learning experiences.

In the STREAMS program, participants learn ocean science, principles of mechanical and electrical engineering, coordinate systems, and project management to design, fabricate, build (See **Figures 1** and **2**), and operate underwater remote operated vehicles with recording capabilities (ROVR). They take classes in underwater photography, learn how to SCUBA dive, and learn about the principles of scientific diving.

Figure 1: Lecture: Coordinate system review.

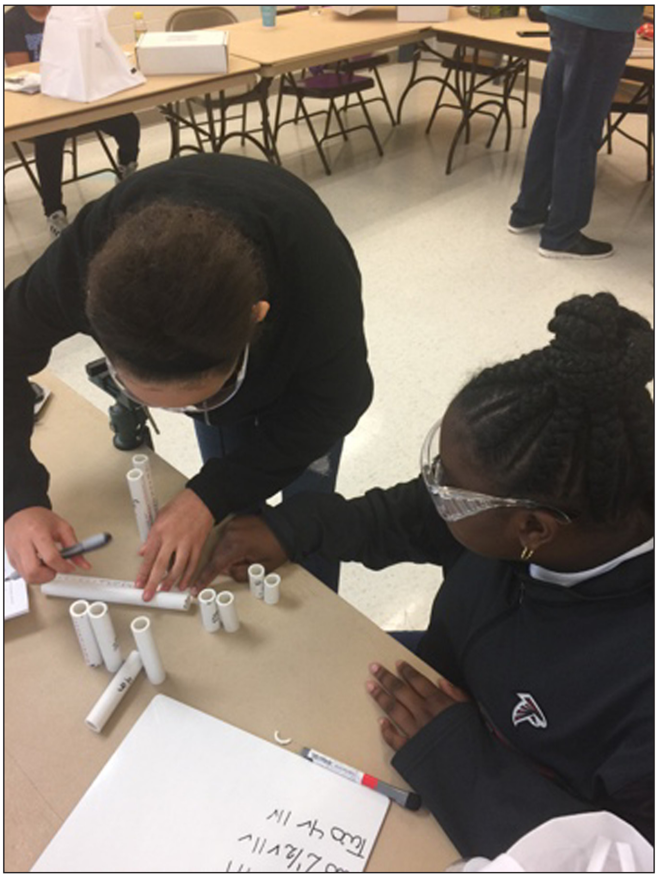

Figure 2: Design and fabrication of ROVR for SeaPerch.

BGDF Digital Badges

Digital badges represent a specific kind of networked technology that recognizes and connects learning across contexts. BGDF has developed over 20 digital badges and 25 micro-badges called CHIPS (Competency Honor Icons of Proficiency) that build to become more complex badges (See **Figure 3**). We are currently working on a badge ecosystem that is recognized by secondary and post- secondary schools for class and experiential college credit, respectively, and by employers. The former is important as participants are learning twenty-first century workforce skills.

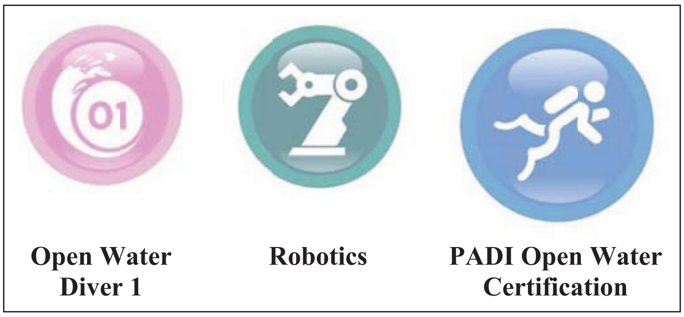

Figure 3: Select examples of digital badges.

Place-based Learning

Place-Based Learning (PBL) is an approach to learning that takes advantage of geography to create authentic, meaningful, and engaging personalized learning. It is an immersive learning experience that places students in local heritage, cultures, landscapes, opportunities, and experiences. A key component of our STREAMS program is utilizing various and relevant learning spaces to cultivate deeper learning, whether through abroad capstone experiences to various islands or frequent visits to environmental nature centers, museums, and aquariums. More specifically, after completing a year's worth of academics, Cohort 2 was able to synthesize their learned experiences and traveled to Forfar International Field Station on Andros Island, Bahamas, where they utilized all they had learned (See **Figure 4**).

Participants spent six days learning about the culture and history of the island, such as visiting the sponge farm and learning about sponges (See **Figure 5**), and learning about and engaging in batiking from the Androsia Batik factory (See **Figure 6**) and basket weaving on the island.

Participants had the opportunity to visit locations on the island where people come to purchase wood carvings and baskets. Much to their surprise, the work of these craftsmen occurred in their private homes. As a result, the girls not only had the opportunity to listen and explore the workmanship but were able to get a perspective on how people on the island lived (See **Figure 7**).

Figure 4: Preparing for boat diving.

Figure 5: Batiking at Androsia Factory lecture.

Figure 6: Sponge cultivation lecture.

Figure 7: Basket weaving educational experience.

Cohort 2 attended lectures on herpetology, invasive species, fish identification, and oceanic versus freshwater blue holes. Here, they were taught by marine scientists of Forfar Field Station. Instruction took place both in the classroom and on location. For instance, in learning about the differences between freshwater and oceanic blue holes, the girls visited an oceanic blue hole and Captain Bill's Blue Hole. Captain Bill's Blue hole is a freshwater blue hole and the largest blue hole on the island, measuring 440 feet across and included an exhilarating 15 foot jump into the water, which the girls enjoyed (See **Figures 8** and **9**). Thereafter, they visited an oceanic blue hole. In both locations, participants conducted water sample testing that included measuring salinity, pH, and water temperature at various depths of each blue hole.

BGDF's signature ocean conservation initiative is *At Depth: From Sea to Shining Sea*. This initiative involves beach and ocean clean-ups that spans from the Atlantic to Pacific Ocean. Cohort 2 kicked off this initiative on Andros Island (See **Figure 10**). As a part of the implementation, the girls identified the issues surrounding the disruption of our ocean's ecosystem, reading about the impact of microplastics on marine life that consume these microplastics and how that disruption impacts our own health as we consume products. This initiative yielded over 100 pounds of collected trash.

Figure 8: Blue holes lecture at Captain Bill's Blue Hole.

Figure 9: Oceanic versus freshwater blue holes lab.

With a year's worth of confined pool diving to hone their SCUBA diving skills, the girls completed their open water checkout dives on Andros Island and became certified Professional Association of Diving Instructors (PADI) open-water divers. They meticulously engaged in multi-dive planning, selecting and learning about the location of their dives, planning their diving depths and calculating surface intervals (See **Figure 11**).

The girls selected A-Flats as the dive site of their first certified dive (See **Figure 12**). This site is located slightly south of Forfar International Field Station near Pigeon Cay. It has a sandy bottom and is around 20 to 30 feet deep. At this site, there is a stunning variety of corals, fish, and invertebrates. During their dives, they observed sting rays, a shark, and schools of fish of many varieties.

Figure 10: Beach Clean Up.

Figure 11: Dive Planning.

Figure 12: First dive as certified divers at A-Flats dive site.

Program Activities, Outcomes, and Impact

To date, BGDF has provided SCUBA certifications and dive specialties that include open water, advanced open water certification, and dive specialty certifications in Whale Shark, Manta Ray and Coral Restoration. Participants have traveled to SCUBA in Andros Island, Bahamas, Sharm El Sheikh, Egypt, and the Florida Keys. Community activities have included visits to the Museum of Natural History to attend a lecture given by an invertebrate specialist (See **Figures 13** and **14**); geocaching and nature exploration for the Annual Easter Egg Geocache event; Robo-A-Thon, where the girls learned about coding and mechanical engineering; and grass planting to prevent shore erosion, to name a few. Moreover, we established five cohorts of girls in the STREAMS program who range in age from 9 to 16 and have erected two additional chapters in BGDF. Those chapters include a recent program at the Georgia Aquarium that will start in the Fall of 2021 and Sprout U School of the Arts, which opened in 2020. In review of outcome data, persistence and retention rates are above 95 percent. Persistence is operationally defined as the number of participants that progress to the next difficulty level in the program; while retention is defined as the number of participants who are retained in the program. BGDF has a four-year retention rate of 97 percent and a cohort persistence rate of 100 percent. One hundred percent of participants reported a greater understanding of their role in sustaining a healthy ecosystem in our waters and land and greater interests in the sciences and understanding of career opportunities in STEM. Participants say, "I like this program because it's different. I get to do things that I have only seen on TV." Other girls focus on the comradery and newly developed relationships. One participant said, "I have made new friends that share similar interests that I have." Our STREAMS program is steadily reaching our goals to improve awareness of careers in the aquatic sciences, access to mentors, and provide professional development skills among participants to directly impact student outcomes and ultimately leading to a stronger, more diversified aquatic science workforce.

Figure 13: Lecture: Coral Types at Museum of Natural History.

Figure 14: Lecture with invertebrate specialist at the Museum of Natural History.

Competing Interests

The authors have no competing interests to declare.

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