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RESEARCH AND EVALUATION

A Case Study in Making Ocean Education Accessible for Students with Special Needs

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Ocean education and ocean-based experiences need to be more inclusive, not only for underrepresented minority students but also for students with special needs. To increase the accessibility of marine science to students in special education, the Young Scientists Program (YSP) hosted an interactive marine science workshop for students in special education classes. During the workshop, students were able to learn the fundamental principles of engineering and engage with the engineering design process by building underwater robots and testing them in an inflatable pool. They were also able to see buoyancy acting on a Cartesian diver while learning about the inverse relationship between the volume and pressure of a gas. The success of this workshop not only demonstrates the positive impact engaging learning experiences have on students in special education but also argues for the inclusion of students with special needs in STEM programs.

Keywords: special education; underrepresented minority students; expanding audiences; elementary school; engineering and robotics

Introduction

The study of ocean science has long been an exciting field with numerous research and professional opportunities that fall under the STEM (science, technology, engineering, and mathematics) umbrella. However, a lack of ocean science literacy in both the general public and academic settings has left students generally unaware of not only the importance of ocean science in their daily lives but also the career opportunities available to them in this field (Strang, 2008). It is therefore critical to improve ocean science literacy. To do this, students must be given opportunities to engage with authentic educational experiences in the field of marine science. The following case study will report on a marine science workshop designed for students in special education. An overview of the workshop activities, as well as the appropriate accommodations, are included. The results of this workshop demonstrate how interactive learning opportunities can be used to encourage science learning in students with disabilities.

Program Overview

As part of the University of Southern California's Joint Educational Project, the Young Scientists Program (YSP) supplements science education delivered to elementary-school students. YSP undergraduate and graduate teaching assistants deliver engaging and interactive weekly lessons to elementary school classrooms in the Los Angeles Unified School District (LAUSD) that focus on a wide variety of STEM topics. On average, 87% of students attending YSP-affiliated schools are eligible for free or reduced-price lunches (CDE, 2019), an indirect measure of socioeconomic status for the district. The majority of students attending YSP-affiliated schools are also students of color: 82% identify as Latinx, 12.62% identify as African American, and 0.1% identify as Native American (CDE, 2019). To provide additional support to its vulnerable students, YSP engages with students outside of the traditional school day. For example, YSP hosts workshops on a bi-annual basis to give students opportunities to further engage with challenging science concepts. In this way, YSP works to bridge formal and informal contexts in order to more effectively provide access to high-quality STEM programming, with the ultimate goal of leveling the playing field for low-income students of color.

YSP has a Special Education Initiative that works to bring STEM curriculum to special education classrooms within LAUSD schools. The YSP curriculum is also differentiated to meet the needs of diverse learners within both special education and general education classrooms. Based on enrollment data from the 2018–2019 academic year, 15% of students participating in YSP are individuals with disabilities. Within this group, there are students diagnosed with physical and intellectual disabilities as well as students who require varying degrees of in-classroom assistance and accommodation as indicated in their respective Individual Education Plans (IEPs) (CDE, 2019). This is reflective of Los Angeles County's special education enrollment of 12.2% (Ed Data, 2019). Before the Special Education Initiative of YSP was founded, students placed in special education classes were unintentionally excluded from the supplemental science program that was offered to their peers. YSP was initially developed for students in fourth- and fifth-grade general education classes, and the lack of awareness and training in special education initially hindered the expansion of the program into special education classrooms. However, following a teaching assistant advocating for the inclusion of special education students and addressing the inequities within the program, special education classes began receiving weekly science lessons designed to fit the unique learning needs of their students. Expanding YSP to include special education classrooms furthered the program's goal of making science accessible to disadvantaged students.

Program Rationale

One of the most effective ways to enhance the representation of students with special needs in STEM fields is to ensure that these students have equal access to educational opportunities in STEM-based subjects (Israel, Maynard & Williamson, 2013). Studies have shown that students in special education classes learn science most effectively through hands-on experiments (Scruggs & Mastropieri, 2007). Additionally, research has shown that students with IEPs may benefit more from inquiry-based science education than their peers without IEPs (Hand et al., 2018). With its focus on interactive lessons and hands-on experiments, YSP is well-positioned to provide STEM education to students with a wide range of disabilities.

The YSP Special Education Initiative also leverages its community partnerships to put on workshops at LAUSD schools that are specifically tailored to the needs of special education students. These workshops focus on what's possible for students with special needs instead of emphasizing their limitations. By fostering this inclusive community, the program is able to reach out to the public and make sure it is differentiating for and accommodating the needs of students with special needs. One of the ways in which YSP plans to incorporate ocean science into this inclusive educational context is to adapt resources such as the Bridge Ocean Education Teacher Resource Center, Centers for Ocean Sciences Education Excellence (COSEE), and the Center for Dark Energy Biosphere Investigations (C-DEBI) into formal and informal educational contexts.

Workshop Design and Preparation

On April 23, 2019, YSP invited 16 third- through fifth-grade special education students, their teachers Alicia Gibbs and Veronica Wilt, and chaperones from Norwood Street Elementary School to the University of Southern California (USC) University Park Campus for a workshop on marine science. An image of the students, teachers, and staff present at the workshop can be seen in **Figure 1**. To begin the workshop, the YSP Special Education Initiative founder and USC graduate student Lauren Clarke gave a presentation that provided an overview of the activities the students would be participating in and placed the students into groups. Following this opening presentation, the students began to participate in the workshop's two stations: Cartesian divers and underwater robotics. Following the completion of the workshop, the special education students and teachers were interviewed so that YSP could qualitatively measure the effectiveness of the marine science workshop with regard to student engagement and content retention.

In the station on Cartesian divers, students were given a water bottle that was about 80% full of water. The students then placed the "diver," which in this case was a plastic pipet covered with a rubber squid, into the bottle. After replacing the cap, students were able to squeeze the bottle and see the squid bob up and down. This station not only taught students the concept of buoyancy but also encouraged them to explore the inverse relationship between the volume and pressure of a gas (Boyle's Law). This station supported students' understanding of the Next Generation Science Standards (NGSS) 3-PS2-1 and 3-PS2-2. By physically manipulating the water bottle, students, like the one shown in **Figure 2**, were able to make predictions about the diver's motion and relate this motion to the forces of buoyancy and gravity, reinforcing the connection to the standards listed above.

Figure 1: Special education students, Norwood Street Elementary School teachers, and YSP staff on the USC campus for the marine science workshop. Photo: Dieuwertje Kast. Reproduced with permission of the photographer.

Figure 2: A student at the Cartesian diver station observing buoyancy's impact on the motion of the "diver," or the rubber squid in the water bottle. Photo: Dieuwertje Kast. Reproduced with permission of the photographer.

The second station of the workshop allowed students to design and test their own underwater robots. During this station, students were placed in groups of three or four and instructed to draw the design plan for their robot. Once the design was approved by a member of the YSP staff, students constructed the body of their underwater robot out of pre-cut sections of PVC pipe and two- and three-way connector pieces. They then added pool noodles to their robot so that it would float. Finally, students determined where to place the motors, which were connected to the PVC pipe with zip ties. They then tested their robot's ability to move in four directions (up-down, left-right) and revised their design accordingly. Three students can be seen with their underwater robot in **Figure 3**. Designing underwater robots encouraged students to use their background knowledge of robotics, circuitry, and fluids they had gained from previous YSP lessons. This experience also allowed students to learn about how marine scientists explore the depths of the ocean to make scientific observations and collect data. This station supported students' understanding of the Next Generation Science Standards (NGSS) 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-3. The process of designing, testing, and revising their underwater robots allowed students to engage with the engineering design process.

To ensure the success of the workshop, undergraduate and graduate STEM instructors were taught how to perform the experiments involved in each of the workshop stations. The instructors were also trained in some of the best practices related to special education pedagogy, such as designing activities to create safe and appropriate learning environments, modifying activities to meet the needs of students, and developing individualized approaches to communication and student expression (Council for Exceptional Children, 2004).

Steps were also taken to ensure the safety of participating students. A YSP staff member was positioned to watch the pool at all times, and an additional staff member accompanied each group of students to the pool when they tested their robots to ensure that mechanical equipment was handled properly and kept dry. YSP staff members can be seen helping students test their robots in **Figure 4**. A minimum staff-to-student ratio was maintained throughout the workshop. Additionally, before the start of the workshop, YSP staff ensured that all of the wiring and motors used for the robots were properly waterproofed.

One of the biggest challenges faced in the process of designing the workshop was determining how to provide realistic marine education in an urban setting. One of the ways that our YSP teaching assistants

Figure 3: A group of three students in the process of building an underwater robot. Photo: Dieuwertje Kast. Reproduced with permission of the photographer.

Figure 4: YSP staff members helping students test their underwater robots in the inflatable pool. Photos: Dieuwertje Kast. Reproduced with permission of the photographer.

brought ocean education concepts to life was by bringing bodies of water (in this particular case, an inflatable pool) to the students, allowing them to engage directly with experiments and simulations related to ocean science.

Accommodations

While students with disabilities benefit from concrete, hands-on science learning opportunities (Scruggs & Mastropieri, 2007), certain accommodations need to be made so that special education students can fully benefit from these activities. Research has shown that accommodations for an activity-oriented curriculum should include cooperative behavior management, methods for facilitating the physical manipulation of supplies, and appropriately supporting and structuring the inquiry process (Mastropieri & Scruggs, 1994).

To support students while they were building their underwater robots, YSP staff made sure to incorporate these best practices. Students were grouped in teams of three to four, and each team had at least one YSP staff member who was responsible for assisting the students if they experienced any challenges. To help with any fine motor control issues, most of the supplies for the underwater robots (PVC pipe, pool noodles) were pre-cut to ensure that they were easy for students to put together. YSP staff members were also trained to ask specific guided questions about the engineering process and allowed each group to take as much time as they needed to build their robots.

Similar accommodations were made for the Cartesian diver station. While this station was less complex than the underwater robotics station and therefore did not require as many accommodations, YSP staff placed the rubber squid on the plastic pipet before the workshop so students would not struggle with this step and could instead focus on learning the science behind the demonstration. A YSP staff member was also assigned to this station at all times to teach the students how to use the pipet and ask guided questions to ensure the students understood the concept of buoyancy.

While it is always recommended to follow best practices, it is equally important to be flexible and supplement established protocols with accommodations recommended by teachers who are familiar with the learning needs of the student(s) receiving instruction. Having worked with this group of students before, YSP staff knew some of the accommodations they would need throughout the workshop. As their classroom teacher described, "Our students require multiple modalities and differentiated instruction for the English language learners; those with auditory, visual or memory processing issues; those who struggle with attention or writing; and/or even those that lack engagement or motivation." Knowing this, YSP staff developed additional multimodal supports that would help students participating in the workshop. An opportunity to draw the design plan for their underwater robot was provided to students who may struggle with writing. Bilingual staff members were present to assist with any language barriers. YSP staff also kept students engaged through encouraging teamwork and the sharing of their work with their classmates. This kept students interested in the experiments while also teaching them the importance of cooperation in STEM fields. Some of these accommodations, such as drawing out design plans and working in groups, can be seen in **Figure 5**.

Figure 5: Accommodations such as drawing out design plans and working in groups led by YSP staff members were made to ensure students were able to meaningfully engage with the material presented at the workshop. Photos: Dieuwertje Kast. Reproduced with permission of the photographer.

Workshop Results: Student, Teacher, and Staff Perspectives

Due to the challenging nature of creating assessments that would capture student knowledge gained during the workshop without relying on reading and writing—subjects some students in attendance had difficulty with—YSP staff decided to collect quotes from students and teachers during and after the workshop to capture the success of the activities qualitatively. While testing his groups' robot design, Xavier exclaimed "This is engineering! I feel like an engineer!" Leilani, a fourth-grade student, also noted that "it was an adventure making underwater robots. It made me feel as if I was a true inventor."

Alicia Gibbs, a Norwood Street Elementary School special education teacher, had the following to say about the workshop:

> "I appreciate the effort that YSP took to reach every student that attended…YSP and its staff made sure to connect with [students'] background knowledge and offered opportunities for the students to use nonlinguistic representations in the form of sketching to create their ideas for their robot. They allowed for cooperative small group learning for students to work hands-on with an assistant or two, which I noticed had an immediate effect of creating a comforting space to engage and support learning. By ensuring a welcoming environment in a new space to learn new concepts, YSP was instrumental in encouraging the students to embrace abstract thinking, practice teamwork skills, and have fun while problem-solving their engineering challenge."

While the workshop's primary goal was to increase the accessibility of science education to students in special education classrooms, YSP also realized the potential impact that the program's staff could have on participating students. One of the classroom teachers stated that "the students were also quick to note that a majority of the science instructors that supported instruction at the workshop were women. Having women, and specifically women of color, serve as role models definitely makes a difference for my students who do not often see women in their home community with college educations actually working in STEM careers." Thus, the workshop addressed two key aspects of YSP's overarching mission: 1) to increase the accessibility of science education to underrepresented minority communities and 2) to provide students with role models that encourage them to consider careers in STEM fields regardless of their ethnicity, gender identification, or socioeconomic status.

Conclusion

With positive feedback from the teachers and students involved, it is clear that having an opportunity to engage in a hands-on learning experience made ocean education more accessible to students with special needs. With the appropriate accommodations, interactive STEM programs can be made accessible to

students with disabilities. Students commented throughout the workshop that they felt like real engineers and mentioned how they "never knew science could be so fun." While they may not have felt like they were in class, it was clear that the students were grasping important concepts throughout the workshop. As the founder of the Special Education Initiative and the YSP staff member who taught this group of students during the 2018–2019 academic year, Clarke noted that some of her students who had struggled with similar engineering experiences in the past were able to successfully put concepts together and build functioning robots at the workshop. The marine science workshop was thus an effective way to teach STEM material to special education students while also exposing them to concepts in marine science.

The growth and development Clarke saw in her students over the academic year is further proof that STEM education should include those with different learning needs. YSP will therefore continue to develop engaging STEM experiences for special education students and advocates that other supplemental STEM-based education programs do the same.

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Competing Interests

The authors have no competing interests to declare.

Author Contributions

Clarke assisted with writing the first draft, incorporated the reviewers' comments while writing a second draft, and edited the document prior to submission. Kast assisted with writing the first draft, helped with later revisions, and provided guidance in the editing process.

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