Informal Education as a Tool to Build Interest in STEM and Outdoor Recreation: Evidence from Summer Youth Camps at Thunder Bay National Marine Sanctuary, Michigan

Executive Summary

Informal education approaches are designed to enhance student interest, knowledge, and engagement in subject matter through hands-on experiences. Such approaches can be particularly effective in natural settings, where they can enhance retention of material while also fostering stronger connections to the environment. Given these benefits, informal education is often an important component of the mission of natural resource management and park and recreation agencies, which seek not only to conserve resources but also to engage the public in outdoor recreation, learning, and stewardship. Programs that integrate science, technology, engineering, and mathematics (STEM) learning with recreation are widely recognized as effective tools for building public appreciation of natural areas and encouraging lifelong recreation participation and stewardship behaviors.

One such entity is Thunder Bay National Marine Sanctuary (TBNMS), which protects 4,300 square miles of Lake Huron, off the coast of northeastern Michigan. In partnership with the nonprofit Friends of Thunder Bay National Marine Sanctuary, TBNMS offers outdoor adventure camps that allow youth to learn about the Great Lakes and connect with nature. Three such camps were offered in the summer of 2023: Underwater Robot Academy, designed to enhance understanding of marine technology and engineering among younger students; and Outside and Unplugged and National Marine Sanctuary Sampler, both of which focused on fostering appreciation for the natural and cultural resources of TBNMS through immersive outdoor experiences.

Student demographics and experiences were evaluated through written assessments administered prior to and following each program. Following Underwater Robot Academy, more students reported being interested in a career in science, although there was less certainty among participants when asked what specific career they desired. Most participants reported being better at problem-solving following participation in the program. Participants in Outside and Unplugged and National Marine Sanctuary Sampler reported feeling more comfortable, confident, and skilled when engaging in outdoor recreation and nature activities, and most reported that the programs increased their confidence to explore the natural world.

These results indicate that the informal education programs offered by TBNMS were generally successful at meeting their goals of increasing participants' interest in STEM, nature, and outdoor recreation. These outcomes further support the idea that informal education programs have the potential to advance the broader objectives of natural resource and park management agencies by promoting environmental stewardship, strengthening community connections to public lands and waters, and reinforcing the roles of parks as essential venues for learning, engagement, and recreation.

Introduction

Informal education programs are increasingly recognized as an important tool, particularly for science, technology, engineering, and mathematics (STEM) learning (Allen & Peterman, 2019). These experiences can increase interest in and awareness of STEM topics and can increase relevant knowledge, understanding, and skills among students (Denson et al., 2015; Kitchen et al., 2018; Maiorca et al., 2021; Roberts et al., 2018). Informal education often provides memorable, hands-on experiences that may not be easily replicated in a classroom setting (Burns et al, 2023a, 2023b; Denson et al., 2015). Additionally, informal educational experiences in nature can result in positive learning outcomes, such as better retention of subject matter, and can also strengthen students' connection to nature and environmental values (Kuo et al., 2019). Thus, offering a variety of informal experiences is of value for STEM education, but may be particularly relevant within the context of education programs led by natural resource management and conservation organizations.

A key goal of many public-facing natural resource management agencies and their partners is to educate and inform the public about key topics and issues relevant to their management mandates (Adams et al., 1986). To that end, numerous agencies offer educational resources or programming designed for youth and adults. For example, the U.S. National Park Service offers a variety of educational resources, including field trips tailored to specific national park sites and youth age ranges that are designed to facilitate meaningful, field-based learning (National Park Service, n.d.). Similarly, the Maryland Department of Natural Resources Wildlife and Heritage Service offers a variety of home-learning resources, as well as numerous hands-on informal education programs for youth and adults, which are designed to build outdoor recreation skills and enhance knowledge about nature and local wildlife (Maryland Department of Natural Resources, n.d.).

Similarly, NOAA's Office of National Marine Sanctuaries (ONMS), which administers 18 marine protected areas across the U.S., has developed education and outreach programs to inform the public about topics relevant to national marine sanctuary management (Office of National Marine Sanctuaries [ONMS], n.d.). Individual sanctuary sites offer a variety of opportunities for students and lifelong learners to learn about and gain an appreciation for sanctuaries, while gaining a better understanding of science and other topics relevant to sanctuary management. Opportunities to engage with and learn about national marine sanctuaries are particularly valuable, as these ocean- and Great-Lakes-based sites can be remote or difficult to access without specialized training. ONMS education programs can offer opportunities to engage with and learn about sanctuaries remotely or via tailored experiences led by knowledgeable staff from sanctuary sites or partner organizations.

One such site is Thunder Bay National Marine Sanctuary (TBNMS), which is located in Lake Huron offshore of Alpena, Michigan, and protects 4,300 square miles of Great Lakes waters, including nearly 100 historic shipwrecks that lie within its boundaries (Thunder Bay National

Marine Sanctuary [TBNMS], n.d.). TBNMS operates the Great Lakes Maritime Heritage Center, which serves as a visitor center that displays exhibits about the sanctuary's history and resources (TBNMS, n.d.), as well as a setting for informal education programming. TBNMS offers programs tailored to all ages, including lectures from Great Lakes experts, glass-bottom boat visits to view historic shipwrecks, and paddling competitions (TBNMS, n.d.). In partnership with the nonprofit Friends of Thunder Bay National Marine Sanctuary, TBNMS also hosts programs geared toward youth, including school visits to the Great Lakes Maritime Heritage Center and summer outdoor adventure camps, which are hands-on programs aimed at improving Great Lakes science literacy and nature connectedness.

In the summer of 2023, three youth camp programs were offered at TBNMS: Underwater Robot Academy, Outside and Unplugged, and National Marine Sanctuary Sampler. These programs were evaluated to understand their impact on participants' perceptions of STEM and nature-based recreational activities. A description of each program is provided below.

Underwater Robot Academy

This three-day program took place in June 2023 and allowed participants to learn about marine technology by designing and building an underwater remotely operated vehicle (ROV). Students piloted the ROVs they built in the Marine Technology and Training Tank at the Great Lakes Maritime Heritage Center and also had the opportunity to pilot a professional ROV in the Thunder Bay River. The goals of the program were to increase participants' knowledge about ROVs and the role they play in marine research, particularly pertaining to marine archaeological resources, while also learning about the maritime and natural resources of northeastern Michigan. Additionally, the program allowed participants to learn about engineering practices, and the role creativity, problem-solving, and teamwork play in the engineering process.

Outside and Unplugged

This four-day program took place in early August 2023 and educated participants about TBNMS and its many opportunities for outdoor recreation. The goal of this program was to inspire participants to step away from the distractions of electronic devices and be present in the moment by engaging with and appreciating the region's unique maritime heritage and natural resources. Participants kayaked to and snorkeled a shipwreck, visited a local state park to learn about sinkholes, climbed the stairs of a historic lighthouse, and cruised on a glass-bottom boat to view and learn about shipwrecks. Students learned about the region's natural and cultural resources through a historical and stewardship-focused lens, while gaining experience in outdoor recreational activities. They documented their experiences in a handwritten journal and learned about ways to experience and preserve TBNMS resources for future generations.

National Marine Sanctuary Sampler

This two-day, one-night program for youth took place in late August 2023 and was designed to promote stewardship and preservation of the Great Lakes and their rich history. The experience included a guided tour of the museum at the Great Lakes Maritime Heritage Center to learn about the importance of preserving historical shipwrecks, as well as a glass-bottom boat tour to view some of these shipwrecks firsthand. The program also included a visit to North Point Nature Preserve to learn about its sensitive ecology and unique plants and wildlife, followed by a kayak trip to experience a nearshore shipwreck firsthand.

Methods

Administrative Structure

All three programs examined were designed and delivered by TBNMS education staff, with fiscal and logistical support from its nonprofit partner Friends of Thunder Bay National Marine Sanctuary. Program costs were sustained through a combination of external grants to Friends of Thunder Bay National Marine Sanctuary, community in-kind support, and in some cases, modest participant fees. The 2023 camp activities and associated analysis of their impact were funded by a National Science Foundation (NSF) grant through West Virginia University to TBNMS, focused on engaging youth in outdoor recreation settings. The parameters set by the NSF grant allowed for a level of community engagement that impacted the Alpena community positively. Economically, the grant infused funding into the community that enabled local schoolteachers to lead the youth education programs during their summer break. Academically, the program replicated and extended educational programs that have been operated by ONMS staff in previous years.

Evaluation

Participant experiences were evaluated by asking participants to complete written pre- and post-tests. The evaluative tools were replicated and modified for use in this specific setting from previous education camp tools (Burns et al, 2023a; Burns et al., 2023b). For the Underwater Robot Academy, the assessment was focused on evaluating interest in science and confidence solving problems, while for Outside and Unplugged and National Marine Sanctuary Sampler, the assessment was focused on evaluating recreation-related self-efficacy and nature connectedness. Although the Outside and Unplugged and National Marine Sanctuary Sampler programs occurred at different times and had different participants, the programs included similar activities and assessments posed the same questions; thus, results for these program evaluations were combined. For all programs, the pre-test was administered on the first day of the camp, before activities began, and the post-test was administered on the final day of camp.

Results

Demographics

In 2023, there were 19 participants in the Underwater Robot Academy camp, ranging from 8–11 years old, and 24 participants in the Outside and Unplugged and National Marine Sanctuary Sampler camps, ranging from 11–18 years old. Participants were primarily from Alpena and other areas of northeastern Michigan, although there were a small number of out-of-state participants. Many participants in the Outside and Unplugged and National Marine Sanctuary Sampler camps were involved in the Boys and Girls Club of Alpena.

Underwater Robot Academy

The pre- and post-test asked participants (n = 18) if they were interested in a career in science. There was a 43% increase in the number of students who responded "yes" in the post-test compared to the pre-test (Figure 1). However, when asked what career they wanted in the future, one fewer participant reported wanting a career directly related to science (Figure 2). Two-thirds of participants reported that they were better at solving problems at the end of the Underwater Robot Academy program (Figure 3).

Figure 1

Responses to the Question "Are You Interested in a Career in Science?" Before and After Participation in Underwater Robot Academy

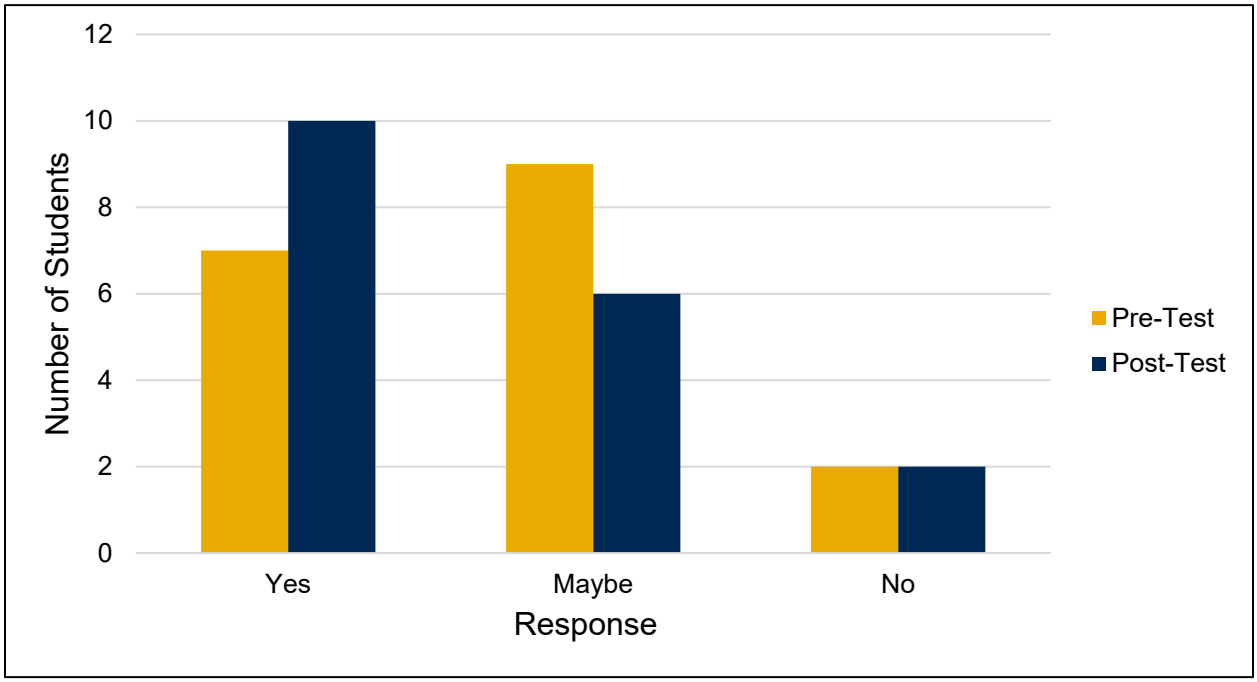


Figure 2

Responses to the Question "What Career Do You Want When You Grow Up?" Before and After Participation in Underwater Robot Academy

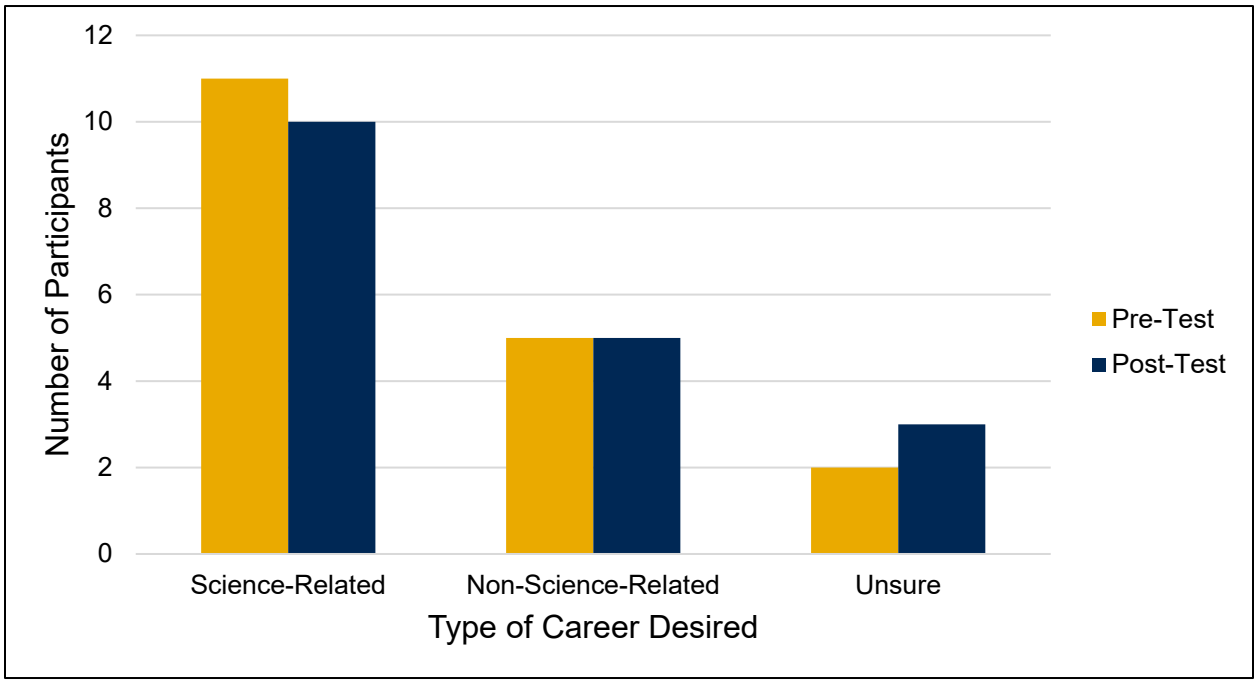
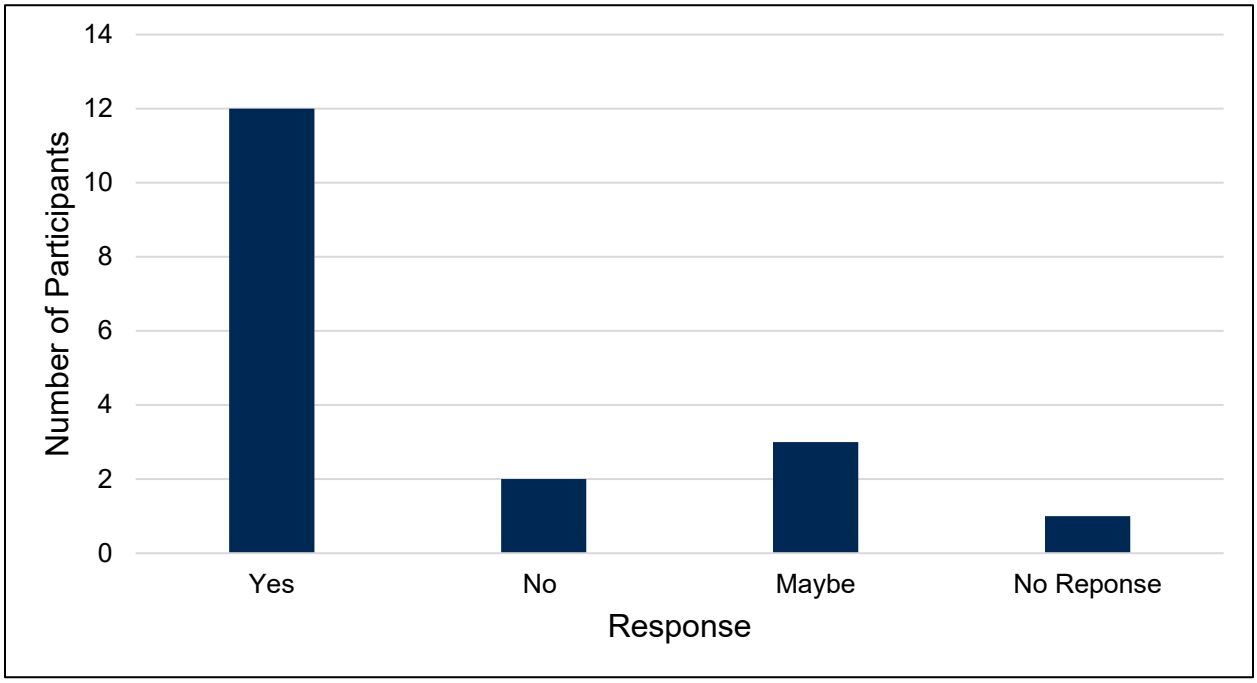


Figure 3

Responses to the Question "Are You Better at Solving Problems?" After Participation in Underwater Robot Academy



Outside and Unplugged/National Marine Sanctuary Sampler

The pre- and post-test asked participants about their level of comfort engaging in outdoor activities. One participant responded to only the pre-test, but not the post-test (i.e., n = 24 for pre-test, n = 23 for post-test). After the camp concluded, there was a 16%, 11%, and 18% increase in the number of students who agreed or strongly agreed when they were asked if they felt comfortable, confident, and skilled, respectively, when engaging in outdoor activities such as hiking, kayaking, and swimming (Figures 4–6). Similarly, while 4% and 8% of students disagreed or strongly disagreed that they felt comfortable and confident, respectively, while engaging in these activities, no students felt this way following the camp experience. There was a particularly positive shift in the number of students who strongly agreed they felt skilled in these activities, with the number doubling following the camp experience; however, in contrast to previous questions about comfort and confidence, one participant disagreed that they felt skilled following the experience (Figure 6). Most participants (79%) agreed or strongly agreed that participation in the camp increased their confidence to explore the natural world (Figure 7).

Figure 4

Level of Agreement With the Statement "I Feel Comfortable Doing Outdoor Activities Such as Hiking, Kayaking, and Swimming" Before and After Participation in Outside and Unplugged/National Marine Sanctuary Sampler

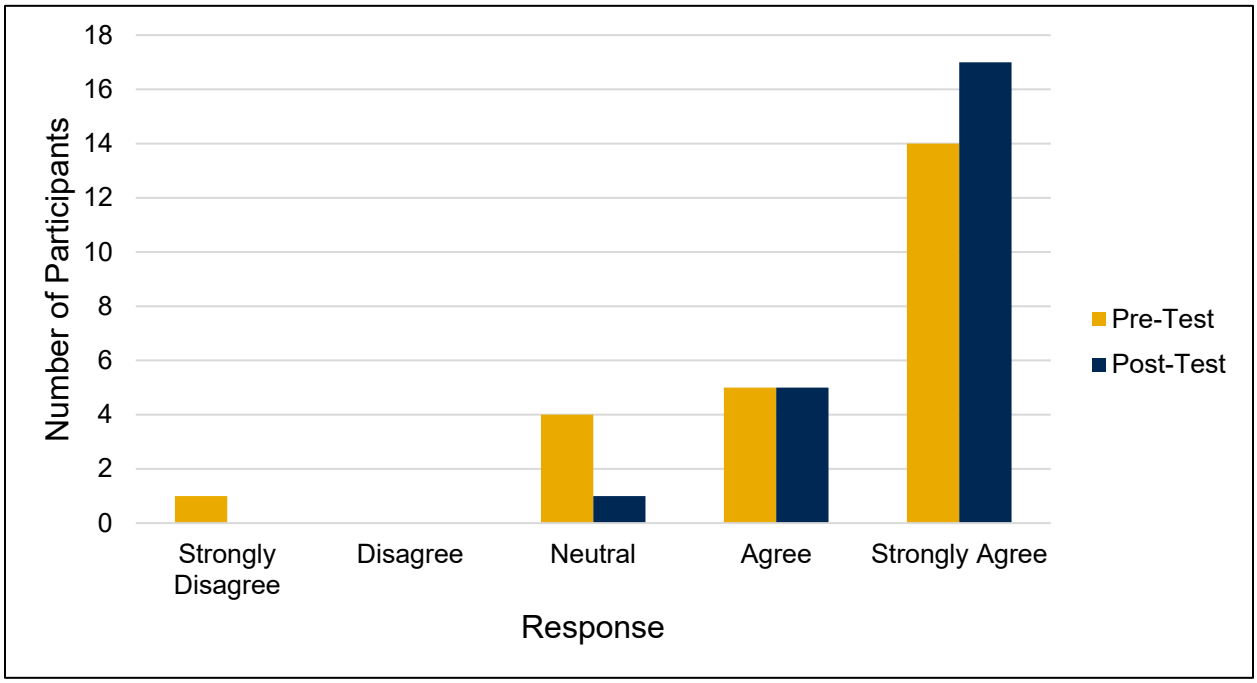


Figure 5

Level of Agreement With the Statement "When I Do Outdoor Recreation and Nature Activities Such as Hiking, Kayaking, and Swimming, I Feel Confident" Before and After Participation in Outside and Unplugged/National Marine Sanctuary Sampler

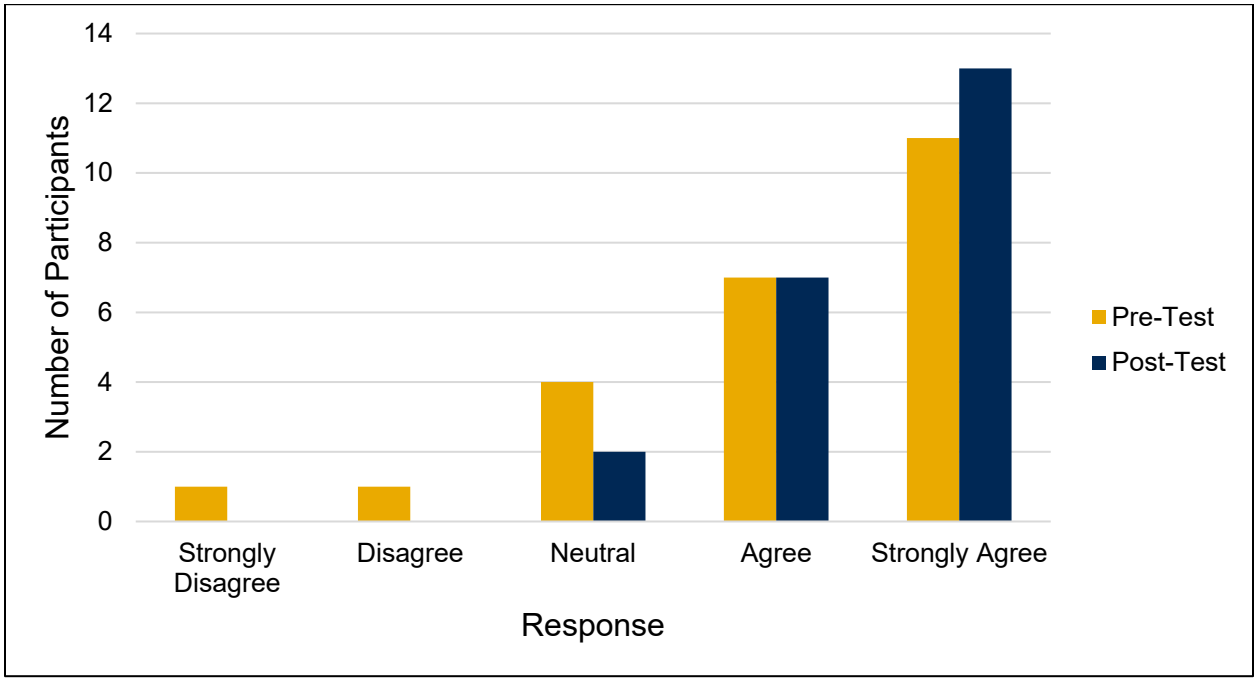


Figure 6

Level of Agreement With the Statement "When I Do Outdoor Recreation and Nature Activities Such as Hiking, Kayaking, and Swimming, I Feel Skilled" Before and After Participation in Outside and Unplugged/National Marine Sanctuary Sampler

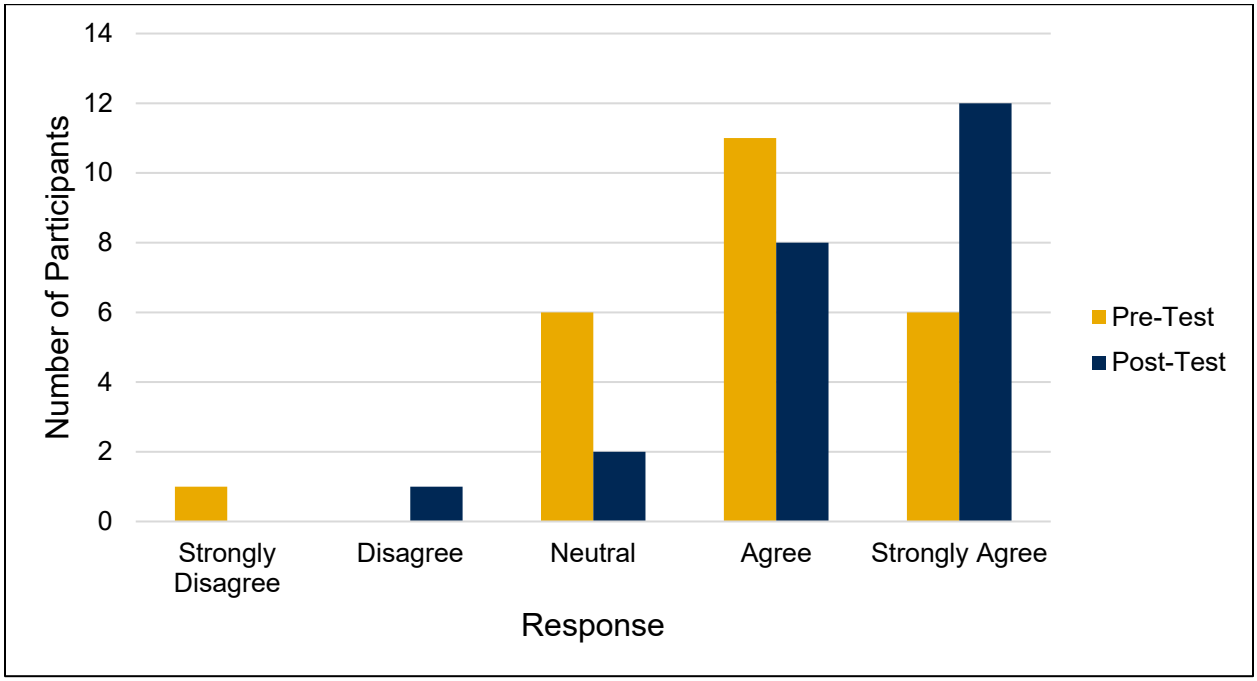
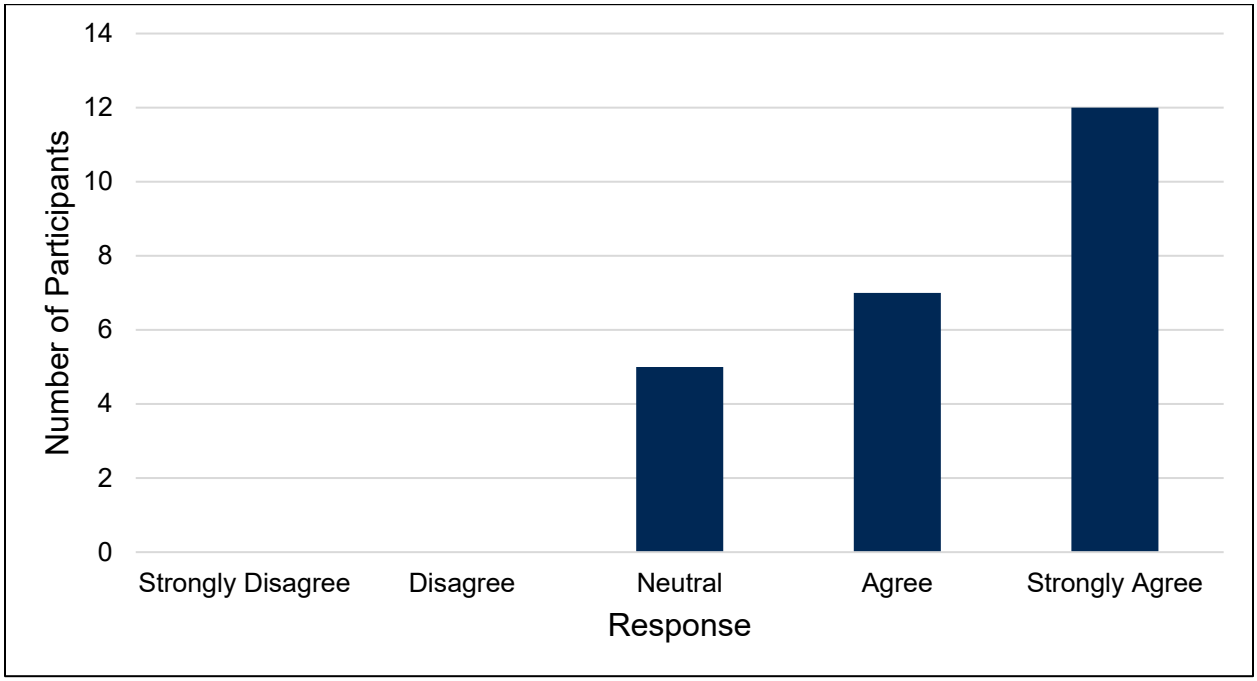


Figure 7

Level of Agreement With the Statement "Participating in This Camp Increased My Confidence to Explore the Natural World" After Participation in Outside and Unplugged/National Marine Sanctuary Sampler



Discussion

In general, students provided positive feedback regarding their experiences in all three programs, which is consistent with positive feedback documented in previous studies of informal education programs focused on STEM (Denson et al., 2015). There was a slight increase in the number of students who reported being interested in a science career following their participation in the Underwater Robot Academy program. This is consistent with the findings of Maiorca et al. (2021), who examined the effects of a one-week summer learning experience in which middle school students participated in hands-on learning, including participation in robotics activities, and engaged with STEM professionals; they found that participation either reinforced or increased their interest in pursuing a career in STEM. Similarly, Kitchen et al. (2018) found that high school students who participated in STEM summer programs were 1.4–1.8 times more likely to aspire toward a STEM career compared with those who did not.

Although the number of Underwater Robot Academy students who reported interest in STEM careers increased following the program, there was little change in the number of science-related careers students reported wanting to pursue before and after the program. Together, the results suggest that while interest in STEM increased, it is possible that students did not have enough information to align that interest with specific career goals; the Underwater Robot Academy program could thus potentially be enhanced by adding additional information or experiences

focused on exposing participants to the variety of program-relevant STEM career options available. Additional studies and a greater sample size would aid in better understanding this discrepancy.

Bicer et al. (2017) examined students' perceptions about creativity and problem-solving skills after participating in an engineering-focused informal education program. Participating in the program gave students a greater understanding of the need for both creativity and problem solving to succeed in engineering-focused STEM disciplines. One of the objectives of Underwater Robot Academy was to similarly give students the opportunity to apply creativity and problem-solving skills in an engineering setting (specifically while building underwater ROVs). Two-thirds of participants reported that they were better at solving problems after participating in the program, suggesting the program successfully met this objective.

In contrast, the objectives of the Outside and Unplugged and National Marine Sanctuary Sampler programs were primarily to give participants firsthand experiences in nature and increase their knowledge about outdoor recreational activities in the region while educating them about TBNMS and the surrounding environment. There was an increase in the number of students who strongly agreed that they felt comfortable, confident, and skilled while engaging in outdoor recreation and nature activities such as hiking, kayaking, and swimming, suggesting that these programs met their objective. Additionally, 79% of participants agreed or strongly agreed that participating in these programs increased their confidence to explore the natural world. A review by Cottrell & Cottrell (2020) showed that outdoor skills education increased participation in outdoor recreational activities and improved environmental awareness and stewardship ethics. The same review also highlighted positive effects on self-efficacy.

Following the Outside and Unplugged and National Marine Sanctuary Sampler, a handful of participants were neutral when asked if they felt comfortable, confident, and skilled while engaging in outdoor recreation, and one participant disagreed that they felt skilled while engaging in outdoor recreation. Examining the outcomes of additional camps of this nature would aid in better understanding their impacts on attitudes toward outdoor recreation. Additional methods, including semi-structured interviews, could also aid in clarifying why some participants did not necessarily feel comfortable, confident, and/or skilled following the experience. Finally, because the most negative post-test responses related to the "I feel skilled" statement, future courses of this nature could increase the focus on outdoor recreation skill-building, and longer courses could potentially be offered, which would increase the amount of time available for participants to build their skills.

Although this study provided important insights into the outcomes of a subset of informal education programs offered at TBNMS, we acknowledge several limitations. First, the sample size was relatively small, with a maximum of 24 participants for a given evaluation. Participation is typically limited by factors such as staff capacity and funding availability. Should increased resources to expand participation become available in the future, these evaluations could be

repeated with larger sample sizes to confirm the present findings. Additionally, if support is available to continue offering these programs annually, outcomes could be compared among and across years. This study also did not include a control group to verify that the observed effects were truly an effect of camp participation. Future studies of this nature should consider incorporating a control group to fully understand the extent to which the observed results can be attributed to the programs examined.

Management Implications

In addition to positively impacting participants, the youth summer camp programs examined here have positive implications for the management of TBNMS and other national marine sanctuaries administered by ONMS. Education is recognized as an important strategy for enhancing public awareness and appreciation of protected areas in both the National Park Service Centennial Act (Pub. L. No. 114–289, 130 Stat. 1486 [2016]) and the National Marine Sanctuaries Act (16 U.S.C. 1431 [1972]). Educational exhibits and programming may be particularly important for raising awareness of national marine sanctuaries, especially those located offshore, which are difficult to visit in person; this may contribute to a lack of recognition and awareness among the general public (e.g., ONMS, 2025). Awareness of protected areas and their resources through education and public engagement is an important prerequisite for the support of and compliance with regulatory measures (Bergseth & Day, 2023). Thus, public education and engagement represent an important factor in generating support for and increasing the overall success of national marine sanctuary management, and ONMS should continue to invest in and develop partnerships for educational programming.

Youth education is a particularly impactful area of focus, as it is well-established that childhood environmental education and experiences in nature are important for shaping positive relationships toward nature and conservation ethic into adulthood (Tanner, 1980; Chawla, 1998; Ward Thomspon et al., 2007; van de Wetering et al., 2022) and fostering environmental stewardship (Borhan & Ismail, 2011). Thus, sanctuary-based environmental education, particularly programs that involve firsthand experiences in nature such as those examined here, can support the development of positive relationships toward national marine sanctuaries. which aligns with ONMS strategic goals (ONMS, 2017). This is also consistent with findings from other national and local park management entities, which have found that youth education programs have had positive impacts on in-park stewardship behaviors (Vezeau et al., 2010) and pro-environmental attitudes (Ferreira, 2012). Investment in early, immersive engagement can thus aid in cultivating long-term stewardship of parks and protected area systems.

A previous study by Schwarzmann et al. (2018) examined opinions regarding and willingness-to-pay for participation in the Ocean Guadian School program, a federally funded grant program coordinated by ONMS that offers hands-on youth educational experiences focused on ocean conservation and stewardship. The study found that parents overwhelmingly supported their

children's participation in the program, and nearly three-quarters of parents reported that participation in the program increased their child's level of responsibility toward the environment (Schwarzmann et al., 2018), consistent with the findings discussed above. Further, although the program was free to participants, parents were willing to pay between $21.41 and $58.52 per year for their child's participation (Schwarzmann et al., 2018). Thus, the value placed on the program by parents exceeded its actual cost, further illustrating the value that communities place on these types of hands-on marine environmental education programs, which can build further support for the national marine sanctuary sites that administer them.

Informal education programs such as those examined here can also have positive economic impacts on local communities. The 2023 summer camp programs offered at TBNMS were supported by a $30,000 investment of NSF funds, which provided support for managers and educators to deliver these high-quality educational experiences to local youth. Although similar programs were offered in previous years, these were paused due to a lack of funding. The renewed investment allowed these programs to restart, boosting the recognition of TBNMS as a key academic entity in the community and creating new work opportunities for local teachers during their summer break, resulting in economic benefits for the local community.

The funding mechanism used to support these summer camp programs highlights the importance of strategic partnerships in supplementing the capacity of park and natural resource management agencies to expand educational and recreation programming. As illustrated in the present example, nonprofit and academic partner institutions can access external funding sources (e.g., NSF grants, university research funds) that are often unavailable to government entities. By developing relationships and working closely with these partners, park managers can ensure that partner-funded projects align with agency missions and management objectives, thereby achieving shared outcomes (Seekamp & Cerveny, 2010). Additionally, community partnerships, such as collaborations with local outdoor outfitters or tourism organizations, can provide valuable in-kind support. A variety of partnerships can thus increase program sustainability and strengthen the role of parks and public lands in delivering educational programs for youth.

Conclusion

Together, the results of this study indicate that the informal education programs offered by TBNMS in the summer of 2023 had positive impacts on participating youth. These results can guide the development of future STEM-focused informal education at TBNMS, as well as other national marine sanctuary sites. Further, these programs have positive implications for natural resource management beyond the immediate benefits to participants. They can foster greater awareness of, support for, and stewardship of national marine sanctuaries and other protected areas, in addition to ensuring these places remain a valued and valuable part of local communities. Offering a range of informal youth education opportunities should thus remain a

priority for TBNMS, as well as the wider National Marine Sanctuary System, and should remain an integral part of the ONMS strategic plan in future years.

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