

## **Building scientific literacy through summer science camps: a strategy for design, implementation and assessment**

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### **Abstract**

*To enhance scientific literacy in the general public efforts are needed that both inspire and engage the learner. Often such efforts are provided through school programs or science learning centers, however, in many rural communities such resources are unavailable. Alternate strategies are needed to provide individuals with quality educational opportunities. One such option is the development of short-term science camps. Science camps can provide both researchers and teachers with the opportunity to disseminate important scientific findings and concepts to a broad audience. Here, we present a brief guide for those educators interested in developing a short-term science camps as a means to promote scientific education and literacy. The aim of this guide is to discuss the potential benefits and caveats associated with running a science camp in rural areas and provide educators with a template assessment for evaluating students' knowledge and perceptions of science. We also discuss the results of a pilot camp offered to seven students in the rural international community of the Exuma Cays, Bahamas. We used using pre- and post-knowledge assessments as well as student self-evaluations to evaluate the effectiveness of the camp. Our findings suggest that these short-term outreach activities can have a positive impact on the scientific literacy and long-term career goals of the participants.*

**Key words:** Scientific literacy, science camps, guidebook, rural communities.

### **Introduction**

At its simplest, the concept of “scientific literacy” refers to the fundamental knowledge that the general public needs to understand about science so that individuals can use that information to make informed decisions regarding personal, civic, and economic matters (Laugksch, 2000; Feinstein, 2010; Rannikmäe et al., 2010). Scientific literacy is less about “doing” actual science but “using” the concepts to gain a perspective and appreciation of the world around them (Hazen, 2002). The term has its roots in the dawn of the space race in the 1950’s (Hurd, 1958). With the launch of the Soviet satellite Sputnik in 1957 there was a period of self-assessment by U.S. residents regarding science education and technological

development (Laugksch, 2000). This self-assessment by both the science community and the political leadership led to the realization that as science and technology rapidly become more sophisticated U.S. progress in these areas is dependent on the public understanding and support of maintaining programs in science education and research (Waterman, 1960). Despite the fact that several decades have passed and an enormous body of literature has focused on the subject (e.g. Laugksch, 2000; Miller, 2002; Miller, 2006), the number of scientifically literate citizens in the U.S. and the world is exceedingly low. Surveys of adult U.S. residents in 2005 found that only 28% were considered to be scientifically literate (Miller, 2006). Other countries around the world showed even lower levels of scientific literacy ranging from 24% in the Netherlands to 2% in Turkey, only Sweden, with 35% of adults scientifically literate, outperformed the U.S. (Miller, 2006; Scearce, 2007). These results indicate that building and enhancing scientific literacy is not just an U.S. issue, but also a global one.

The importance of developing a scientific literate society is multifaceted. First, increasing scientific literacy has been considered to be a critical strategy for maintaining a country's technological and economic standing (Lewis, 1982; Hazen, 2002; Scearce, 2007; Marques Vieira et al., 2011). Over the past few decades the growth rate of jobs in the science and technology sectors in the U.S. has dramatically increased. These new jobs, however, have outpaced the number of qualified, trained individuals who are able to fill them (Scearce, 2007). Second, science and technology has expanded and merged into the daily lives of everyday people with issues such as climate change, pollution, and available energy resources. It is increasingly important to have a scientifically literate society to make informed decisions regarding policy development and its implementation. Lastly, as the global economy grows and becomes more integrated it is increasingly important to expand and improve scientific literacy beyond U.S. borders. Scientifically literate international communities can use this knowledge to understand natural phenomena such as climate change, and potentially use the scientific insight to improve their local agricultural and marine practices, economies and educational systems.

With only a fraction of the adult population scientifically literate numerous strategies have been implemented to reduce this gap (Hazen, 2002; Scearce, 2007). The primary area of focus has been on the K-12 classroom, where through the work of the National Research Council, national teachers organizations and the American Association for the Advancement of Science a series of National Science Education Standards have been generated that attempt to provide guidelines for the development of inquiry-based science curricula for science educators. Retooling and revising science curriculum over the past few decades have made improvements regarding scientific literacy. In the U.S. there has been an 18% increase in the number of scientifically literate adults from the early 1990's (Miller, 2002) indicating that these reformation efforts are successful with sufficient investments of time and financial support. Other strategies to boost scientific literacy outside the K-12 classroom include undergraduate science education, science learning centers, such as museums, zoos and aquariums, and summer science camps. In the U.S. non-majors are often required to take science courses to fulfill their general education requirements, whereas their undergraduate counterparts in Japan and Europe are not (Scearce, 2007). Evidence has shown that the number of science courses taken in college has had a significant impact on the scientific literacy of adults (Miller, 2002). Informal education such science learning centers, public libraries, and science articles published in magazines or the internet also have a pronounced impact on science literacy (Miller, 2002; Hazen, 2002). Previous surveys have shown that U.S. residents are twice as likely to go to a museum or public library than their European

counterparts and six times more likely to visit a zoo or aquarium (National Science Board, 2006). The differences are thought to contribute to the gap in scientific literacy between the US and Europe (Searce, 2007). The difficulty, however with undergraduate education programs and science learning centers is that in rural communities access to these facilities can be limited.

### **Science camps as alternative learning environments**

One alternative strategy for informal science education that bridges the gap between incomes, geographic location, and prior science experience are short-term science camps. Science camps provide a focused, mobile means of introducing scientific concepts to students with a wide array of educational backgrounds. Instead of students coming to the educational resource, such as a school or a zoo, the science educators and learning materials can go directly to the student providing both domestic and international learning opportunities to improve scientific literacy. The use of science camps to promote informal education is wide spread, however, few studies exist that examine the effectiveness of these camps on changing student's outlook and improving scientific understanding (Fields, 2009). Of those studies that do examine the effectiveness of science camps, most show that participating in a short-term science program can have a positive impact on the perceptions and learning achievements of the students, whether it pertains to reading proficiency (Schacter and Jo, 2005); computing (Doerschuk et al., 2007); laboratory skills development (Knox et al., 2003), or hands-on research experience (Fields, 2009). However, few of these studies have examined the link between science camps and scientific literacy or have examined the effectiveness of science camps in motivating students from rural areas (Martinez and Hibbs, 2003).

### **Building a science camp in a rural international community**

To build off of these previous studies and enhance scientific literacy in rural communities beyond the U.S., a pilot science camp was developed that focused on key concepts such as environmental sustainability, climate change, ocean acidification and the processes of scientific inquiry. The pilot camp was held on the island of Little Darby, which is part of a remote archipelago known as the Exuma Cays located in the Central Bahamas. The Exuma Cays were chosen for the camp locale, as it is an active site for scientific research on modern stromatolites. Stromatolites are microbial ecosystems that sequester carbon dioxide through a wide range of metabolisms as the mineral calcium carbonate (i.e. limestone; Grotzinger, 1999). These carbon-sequestering communities are thought to serve as analogues to the oldest known ecosystems on the planet and provide critical insight into how life originated on the early Earth (Reid, 2000).

Since this remote archipelago is an active site for field research, it became an important concern for researchers to ensure that the residents of these islands were aware of the stromatolites in their oceans and the role these ecosystems play in larger environmental issues, such as ocean acidification and climate change. To address these concerns the camp was developed in collaboration with the Bahamian Marine EcoCentre (BME; formerly the Danguillecourt Project; <http://tropicbirds.org/>), a non-profit organization that is familiar with both the culture and logistics of the Exuma Cays and is dedicated to preserving the Bahamian environment through both artistic and scientific endeavors. The educational component of BME is the Young Bahamian Marine Scientists (YBMS) program, which runs many informal educational activities throughout the Bahamas (<http://tropicbirds.org/ybms/>). Together with YBMS, we developed a one-week summer science camp that targeted school-aged children (ages 9 - 18) living in the vicinity of Little Darby in the southern Exuma Cays.

## **The Design**

The camp was held over a six-day period in August 2010 at the Little Darby Research Station. The research station was built in 2009 through a cooperative effort by the Bahamian Marine EcoCentre and the University of Miami and is dedicated to protecting the Bahamian environment (<http://tropicbirds.org/research.html>). The objective of the science camp was to expose students from these rural communities to scientific concepts that directly relate to the Bahamian environment and economy. Four of the six days were dedicated to specific scientific topics and included: understanding the scientific method; geologic and oceanic sciences; biological sciences; and the future of science and technology (Table 1). Each of the four “science” days were broken up into four distinct categories (Table 1) and included: a morning lecture; a midmorning scientific exercise that reinforced the morning topic; a post-lunch physical activity; and a field work exercise that enabled the students to incorporate the content of the morning lecture into the natural environment. Regular breaks were included in the schedule to allow students to get a snack, cool off with a swim or rest between activities. The fifth day was dedicated to exploring the Exuma Cays Land and Sea Park, the first land and sea preserve in the world established in 1958 and one of the few no fishing zones in the Bahamas ([http://www.bnt.bs/parks\\_exuma.php](http://www.bnt.bs/parks_exuma.php)). For the field trip to the Exuma Park the schedule was more informal than the previous days and six key sites within the park were selected (Table 2) to provide the students with several outdoor lessons that described issues such as the local flora and fauna of the park, impact of fishing (e.g. size limits) on ecosystem sustainability, and role of the mangroves in ecosystem health (Table 2). Students were able to see first hand the positive outcomes of conservation efforts in their own environment. The last day of the camp provided the students with the opportunity to present to their parents and local community what they had learned during the week-long camp. Time was set aside earlier in the week for students to start thinking and outlining the topic and nature of their scientific presentation. Students were encouraged to use creative thinking and innovative approaches to communicate to their families and community leaders their learned knowledge.

## **The implementation**

### **The Educators**

One of the critical aspects of working with international students and communities on science education is involving local educators. Even if one has conducted research for several years in the area coming into a community and implementing an educational curriculum, even if it is short-termed, can be seen as invasive. This aspect is also applicable to rural domestic areas where local communities may question the intent of the incoming educators and the scientific message. To alleviate this concern we collaborated with Bahamian educators and student interns from the YBMS program to modify the curriculum materials such that they fit Bahamian economic and environmental policy issues. While the overall scientific content was the same, the YBMS educators assisted in provided current local examples of how these global issues impact the young Bahamian students and their community in the Exuma Cays.

### **The logistics**

The logistics of putting a one-week camp together required three key elements: the recruitment of students from the nearby islands; development of a transport and meal plan for the students and educators; and acquiring and importing the learning materials for the scientific curriculum. Two approaches were used to recruit students to participate in the camp: contacting local schools prior to the end of the school year; and contacting local political leaders to assist in increasing the awareness of the camp. For this camp, contacting the local government official was very successful and most of the students that attended the camp were

the results of this approach. Due to the limited size and infrastructure of the Little Darby Research Station the camp was run as a day camp with only a few evening activities.

**Table 1.** Overview of the design, activities and scientific concepts addressed in the international summer camp

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
08:00	Arrive at Little Darby	Arrive at Little Darby	Arrive at Little Darby	Arrive at Little Darby	Field Trip to Exuma Cays Land and Sea Park	Arrive at Little Darby	
08:30	Icebreakers	Icebreakers	Icebreakers	Icebreakers		Icebreakers	
09:00	<b>Classroom Lecture:</b> Pre-camp surveys. Introduction to the scientific method.	<b>Classroom Lecture:</b> Introduction to stromatolites, carbon cycle, pH, and climate change.	<b>Classroom Lecture:</b> What is DNA and how can we use it in everyday life?	<b>Classroom Lecture:</b> What is NASA? What do stromatolites have to do with NASA?		Work on skits or podcasts for presentations to parents and community.	
10:30	break	break	break	break		break	
10:45	<b>Scientific Exercise:</b> Identify the mystery canister using the scientific method.	<b>Scientific Exercise:</b> Ocean Acidification - examine the impact a lower pH would have on the oceans; practice taking pH measurements.	<b>Scientific Exercise:</b> CSI Darby - Isolate your own DNA <sup>a</sup> .	<b>Scientific Exercise:</b> Alka-Seltzer Rockets -Students learn about data tables, independent and dependent variables.		Work on skits or podcasts for presentations to parents and community. Post-camp surveys.	
12:00	lunch	lunch	lunch	lunch		lunch	
12:45	<b>Scientific Method Obstacle Course:</b> Students navigate their way through the obstacle course to get a piece of the scientific method puzzle.	<b>Nature Hike:</b> Visit Little Darby Salt Pond to observe the local flora and fauna of the island.	<b>Communication Skills:</b> Students start to work on their science presentations.  <b>Break out:</b> Students can use podcasting to create a public service announcement of an important issue they learned about in camp.	<b>Field Work:</b> Geocaching: Global Positioning Satellites are an important resource to navigating in and around the Bahamas. Students will learn to use GPS to find hidden clues on Little Darby.		<b>Community Picnic, Camp presentations and student rocket launch.</b>	
14:30	break	break	break	break			
15:00	<b>Field Work:</b> Snorkel Safety Review; Practice snorkeling. Underwater treasure hunt (with real treasure!).	<b>Geology Field Work:</b> Stromatolite underwater mapping. Students record stromatolite and sand depths then convert those recordings into an underwater map of the area.	<b>Biology Field Work:</b> Survey of macro and microorganisms that live within stromatolites.	<b>Rocket Construction:</b> Build your own rocket. There are many design approaches that students can take.			
18:00	Head for home	<b>Community Dinner</b>	Head for home	Head for home		Head for home	Head for home
19:30		<b>Starry Night:</b> Evening lesson on the night sky and use of telescopes to stargaze					
22:00							

<sup>a</sup>Activity was based on publication by Fajardo-Cavazos and Nicholson, 2007

Food for the students and educators had to be flown in from Nassau, as there are no supermarkets on these particular islands of the Exuma Cays. Not only the number of students, but the age of the students impacted the food budget and planning. Again due to the limitations with the infrastructure on Little Darby, the educators prepared meals. Rotating the meal planning duties with teaching duties was essential to adhere to the camp schedule. However, if possible, we recommend including a staff person dedicated to the food budgeting and meal preparation efforts to reduce the workload on the educators. Most of the learning materials used in the camp were brought with those educators from the U.S.. Working with local non-profit organizations can reduce or remove the costs of taxes and duties imposed on education materials brought into the target country. In the Bahamas 70% of the government revenue is derived from duty imports (<http://www.thebahamasguide.com/facts/taxes.htm>), therefore, it is essential to research and include duty costs in budgeting international camps and programs.

**Table 2.** Activities and learning objectives associated with the field trip to the Exuma Cays Land and Sea Park.

<b>Location</b>	<b>Description</b>	<b>Objective</b>
Danger Reef	This reef is located on the Exuma Sound side of the archipelago in ~70 feet of water and is home to schooling jacks, large black, tiger and Nassau groupers along with Caribbean reef sharks.	For students to gain experience snorkeling in deep-water, natural habitats and observe healthy populations of native fish.
Warderick Wells	This cay is home to the park headquarters. On sight is a visitor center with historical artifacts and resource information regarding the cay. The beach has a skeleton of a sperm whale. The island itself contains diverse habitats that include a mangrove creek and the rare Bahamian hutia, an endangered mammal that for many years was considered to be extinct.	For students to learn about native animal populations within the Bahamas; walk through the mangrove creek and identify the four species of mangroves found within the Bahamas; understand how mangroves serve as nurseries for juvenile fish and stingrays.
Pirates Well Stromatolites	Stromatolites are found in the channel of Pirates Well and are located in 20 feet of water This site demonstrates the impact of periodic burial events on stromatolite development.	For students to observe stromatolites in other, deeper locations than those on Little Darby.
Pasture Cay - Sunken Airplane	A healthy soft coral reef that is frequented by schooling fish, lobsters, conch and rays. This reef is a prime example of the successful conservation efforts of the Exuma Cay's Land and Sea Park and the positive impact Marine Protected Areas can have on coral reefs.	For students to observe the increased abundance and diversity of species found on reefs inside the park compared to those outside of the park; to discuss the impact of Marine Protected Areas and their role in marine conservation.
Secrete Creek	A sand flat that is exposed at low tide and is encircled by red mangroves. This site serves as an ideal location for an outdoor class.	For students to appreciate the beauty of the Bahamas and engage in discussions about various scientific concepts.
Thunderball Grotto	A small cay that due to the processes of chemical erosion has hollowed out the inside to form a cave. The inside of the cave has speleothems and small reef fish frequenting the entrance and exit of the cave.	For students to gain a basic geological understanding of cave formation in the Bahamas and experience the biological diversity of organisms living in a Bahamian cave ecosystem.

### **The students**

We left specific criteria regarding the age, background, and skill level of the students up to the local island official who assisted us in recruitment. We simply encouraged all school age children at or above fourth grade level to attend the camp. As this was a pilot camp we wanted to keep the number relatively small and we had seven school age students (age 9 - 18) and one older student (age 19) who served as mentor to the others. All of the camp attendees were male and Afro-Caribbean descent.

### **The activities**

The science lessons and exercises were adapted to work with a wide range of student ages and knowledge backgrounds. We downsized certain lesson plans for the younger students and gave extra puzzles or problem sets to the older students to complete. Specific examples of science exercises and activities are listed at [jamiefosterscience.com](http://jamiefosterscience.com)\*. A few of the students had difficulty with basic reading and writing skills. For those students interns from the University of Florida and YBMS provided them one-on-one attention for several of the science exercises and activities. One of the key features of the camp was to incorporate aspects of local Bahamian culture into the science activities to make the activities more relevant to the participating students. We approached this in two ways. First, each morning before the main science lecture we had an “icebreaker” session (Table 1) by the YBMS educators that described a local environmental issue using Bahamian English accompanied with a short slide presentation. Second, we included a field exercise or group demonstration that reinforced the morning concept. For example, one issue that we addressed with the students was the invasion and impact of the Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) on local Bahamian fisheries. Lionfish are thought to have been accidentally introduced to the coastal waters of Florida from an aquarium during Hurricane Andrew in 1992 (Courtney, 1995). Between 1996 and 2006 lionfish have spread north as far as Rhode Island and southward throughout the Caribbean (Whitfield et al., 2007). These predatory lionfish have had a devastating effect on Bahamian fish populations and have caused reductions in the recruitment of native fishes by 79% in some controlled local experiments (Albins and Hixon, 2008). Although lionfish are edible, some local fishermen have been hesitant to capture or eat lionfish due to the presence of venomous spines. Efforts by local agencies, such as the Bahamian Department of Marine Resources, have attempted to educate local communities on the proper methods to handle and clean the lionfish, first aid, and disposal of lionfish spines. We incorporated discussions on the impact lionfish are having on Bahamian fish populations, as well as fish cleaning demonstrations and gut content dissections and examinations. Incorporating culturally relevant activities that address local issues provide the camp attendees the opportunity to increase their awareness of their own environment.

### **Community Outreach**

To complement the day camp we organized two additional events that included the families of the camp attendees, as well as local community members. The first event was an evening of stargazing along with a barbeque dinner on Little Farmer’s Cay, one of the more populated islands in the area where most of the students live. Aspects of astronomy, constellation identification and celestial navigation were discussed with the local residents. In addition to the stargazing event we invited the families and local officials on the final day of camp to watch series of student presentations that included slide shows, podcasts, public service announcements and student-built rocket launches. Residents were also provided with a lionfish cleaning demonstration that was led by one of the older students and lionfish hors

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\* <http://jamiefosterscience.com/education/outreach/summerScience2010/summerCamp2010.html>

d’oeuvres so residents could sample and taste the fish. Community leaders were presented with copies of the camp curriculum workbook along with some camp souvenirs. The objective of these community outreach activities was to connect with the local residents and reinforce to the students that their efforts in learning this new scientific material can be a positive and rewarding experience.

### The funding

There was no fee for the students to attend the pilot summer camp as most, if not all, of these students came from rural, low-income families. The camp was primarily supported by the Bahamian Marine EcoCentre, which provided funds for student and educator transportation as well as the use of the Little Darby Research Station at no cost. The food was donated by Super Value Food Stores Ltd., and Winfield Rolle, a restaurateur from Nassau, Bahamas. Other benefactors of the camp included the authors, as well as the owners of Little Darby Island, who provided free access to the island’s natural resources and assisted in some of the camp educational activities. Camp souvenirs and some educational materials were provided by the G.E. Foundation and the NASA Summer of Innovation program, which is a U.S.-based program to motivate students in Science, Technology, Engineering and Mathematics education.

**Table 3.** Template of the pre- and post-camp surveys used to assess the students’ perceptions of science.

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WHAT ARE YOUR PERCEPTIONS OF SCIENCE?  
Please indicate to which level you agree with the following statements.  
5 = strongly agree/ Yes, definitely  
4 = Agree/Yes  
3 = Neutral/Some  
2 = Disagree/Not really  
1 = Strongly Disagree/ Absolutely Not

	5	4	3	2	1
<b>Pre-Camp Survey</b>					
I enjoy learning about science	5	4	3	2	1
I feel comfortable with science and think I am pretty good at it	5	4	3	2	1
Maintaining the environment is a very important part of the Bahamian economy	5	4	3	2	1
I think science is an important part of my education	5	4	3	2	1
I am taking this camp because I want to	5	4	3	2	1
I am taking this camp because my parents made me	5	4	3	2	1
When I finish school I want to go to college	5	4	3	2	1
When I finish school I want to become a doctor or nurse	5	4	3	2	1
When I finish school I want to have a career in science	5	4	3	2	1
<b>Post-Camp Survey</b>					
I enjoy learning about science	5	4	3	2	1
I feel comfortable with science and think I am pretty good at it	5	4	3	2	1
Maintaining the environment is a very important part of the Bahamian economy	5	4	3	2	1
I think science is an important part of my education	5	4	3	2	1
I enjoyed this camp and though it was fun	5	4	3	2	1
I learned a lot about science in this week	5	4	3	2	1
When I finish school I want to go to college	5	4	3	2	1
When I finish school I want to become a doctor or nurse	5	4	3	2	1
When I finish school I want to have a career in science	5	4	3	2	1
My favorite part about camp was the following:					
My least favorite part of camp was the following:					

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### Assessments of the effectiveness of the camp

#### Students’ motivation for camp participation

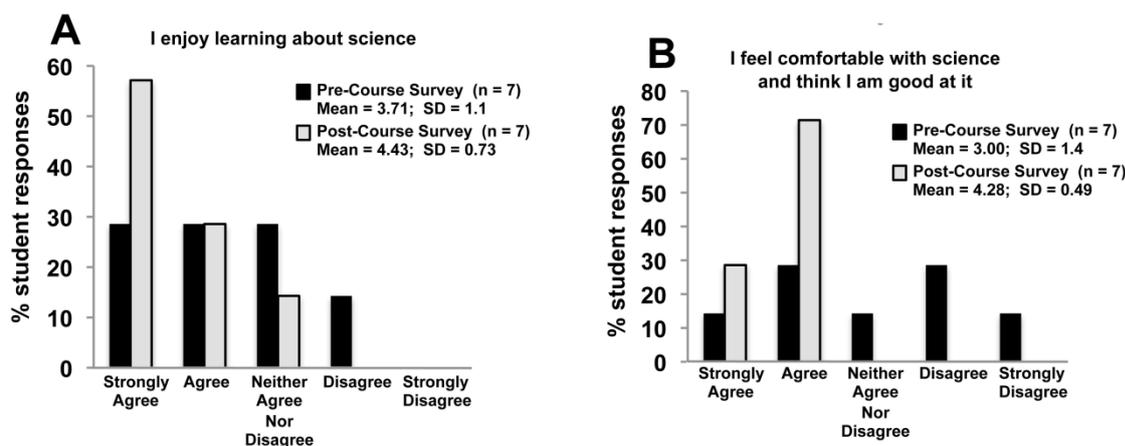
Motivation and peaking student interest in learning is a critical component of science education (Rannikmäe et al., 2010). To address this issue students were asked in a pre-camp survey of their motivation for coming to the science camp and their perception of the role science plays in their lives. Students were asked a series of questions and asked to respond

using a Likert scale (Likert, 1932). The Likert scale ranged from: strongly agree (5), agree (4), neither agree nor disagree (3), disagree (2), and strongly disagree (1). First, we asked students two questions: 1) whether they came to camp because they wanted to; or 2) whether they only came as a result from pressure from their parents. Most of the students (71%) indicated that they came to camp because they wanted to, one student was neutral and one student disagreed, indicating that he did not come to camp voluntarily. However, when we asked whether their parents “made” the students participate in the camp just under half of the students (43%) agreed or strongly agreed that their parents had a significant influence on their camp attendance whereas the remaining 57% of the students disagreed or strongly disagreed. Understanding the students’ motivation for participating in these informal educational activities can help us to engage the student and potentially overcome any ambivalence the students may have towards participating in these learning activities. In the future we recommend adding survey questions such questions such as “How did you hear of this camp?” “Would you recommend this camp to other students?” “What motivated you to come to camp?”. These additional questions may help improve future recruitment efforts of students who are enthusiastic about participating in a science camp experience.

### Students’ perceptions of science in their lives

Prior to the start of camp students were asked questions regarding their perceptions of the role that environmental sustainability and science plays in their lives and community (Table 3). Encouragingly, all of the students (100%) strongly agreed or agreed that maintaining the environment was a critical part of the Bahamian economy. These results mirror the concern and level of engagement that other learners from medium and low-developed countries exhibit (Trumper, 2010). Also most of the students (71%) thought that science was an important component to their education, whereas two of the students disagreed. By the end of camp the number of students that agreed or strongly agreed that science was important to remained the same (71%) however the two students that disagreed before camp were neither agreed nor disagreed on the subject, suggesting a modest change in their perceptions of science.

We also asked students whether they enjoyed learning about science before and after the one-week camp (Fig. 1). Prior to the start of camp approximately half (57%) of the students indicated that they strongly agreed (28.5%) or agreed (28.5%) with the statement that they enjoyed learning about science (Fig. 1A).



**Figure 1.** Students’ perceptions and comfort levels with science. A student t-test was used to statistically compare the responses in the pre- and post-camp surveys.

After the one-week camp these numbers increased by 28.5% with 85.6% of students indicating they enjoyed learning about science. We also asked students to self-assess their own abilities in science (Fig. 1B). Prior to camp there was a wide range of responses with an equal amount of the students strongly agreeing (14.3%) or agreeing (28.5%) that they are comfortable in science with those students that strongly disagreed (14.3%) or disagreed (28.5%). In the post-camp survey there was significant improvement ( $p = 0.02$ ) in the student's confidence in science, with all of the students either agreeing (71%) or strongly agreeing (28.5%) that their understanding of science improved during the camp. While we acknowledge that with a limited number of students in the pilot camp few conclusions can be drawn from such assessments, the results, however, do provide encouragement that these short-term mobile science camps can have a rapid impact on the opinions and perceptions of the camp attendees.

### **Students' scientific literacy**

As encouraging as the students' newfound confidence in science was, it did not, however, necessarily translate into significant improvements in student science knowledge. In addition to the students' self-assessment students were asked to take a short multiple-choice quiz on aspects of science that were to be discussed in the camp. The same quiz was given on the first and last day of camp. There were four key areas of the quiz that correlated to the main topics of the camp including: 1) the scientific method and how one conducts a scientific experiment; 2) geological and oceanic processes associated with global climate change and ocean acidification; 3) the role that microbes play in the environment and in human health; and 4) how new scientific technologies can help improve the quality of life and our understanding of the world around us. All of these broad topics were discussed in the context of Bahamian stromatolites, which are actively growing in the Exuma Cays. Examples of some of the discussion topics included "What role do stromatolites play in global climate change?", "What are some characteristics of the microbes associated with stromatolites?", and "What role can stromatolites play in the exploration of space and future technology?"

The results of the knowledge assessments are presented in Table 4. A student's t-test was used to statistically compare the pre- and post-camp knowledge survey results. In most areas there were modest improvements in the students' understanding of key topics. The only significant improvement was the students' understanding of the role that greenhouse gases play in the global climate ( $p \leq 0.04$ ). Other areas where students seemed to modestly improve was the role of the sun in Earth's climate and the role that microbes play in human health. Two areas where students did not show any improvement included understanding the fundamentals of the scientific method and the physical principles associated with a rocket launch. The lack of understanding on these two areas may reflect the age or literacy level of the students, or these deficiencies may indicate that the delivery mechanisms for this content and the associated exercises may be inadequate. Knowledge assessments such as these multiple-choice tests can serve to modify the class curriculum and fine tune the lecture materials and class activities to improve the students' understanding of the material and the fundamentals of how science is conducted.

### **Looking ahead: students' vision of their futures**

In addition to improving scientific literacy we also wanted to inspire the students to continue to participate in science-related activities beyond the camp. Students were asked before and after the one-week camp whether they had interest in pursuing a career in science (Fig. 2). Prior to camp most of the students (86%) expressed no interest in a career of science (Fig.

2A) however, after the camp there was a significant increase ( $p \leq 0.04$ ), with more than half of the students (57%) interested in a science career.

**Table 4.** Knowledge assessments of science camp attendees.

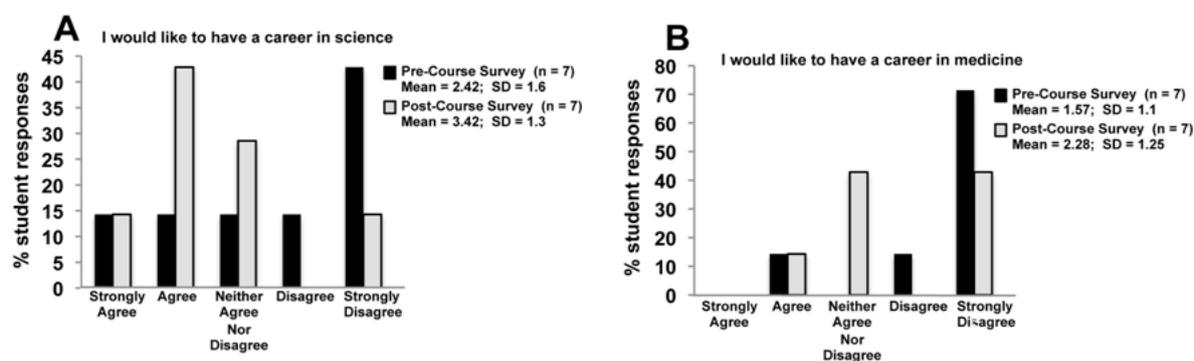
Questions <sup>a</sup>	% correct responses		
	Pre-camp <sup>b</sup>	Post-camp	p-value
A scientific hypothesis is an educated guess based on observations and your knowledge of a topic.	42.9	42.9	0.5
A correct order of the scientific method is: identify the problem, form a hypothesis, do an experiment, analyze the data, communicate the results <sup>c</sup> .	42.9	71.4	0.18
The sun is the primary source of energy that keeps the Earth warm.	71.4	100	0.09
Greenhouse gases trap heat and warm the Earth.	57.1	100	0.04
Carbon dioxide is released when fossil fuels are burned.	71.4	85.7	0.18
Stromatolites are rock-like structures that are made by biological organisms.	71.4	85.7	0.30
Humans need bacteria to live healthy lives.	57.1	85.7	0.09
The oxygen in the atmosphere primarily comes from photosynthesis.	85.7	85.7	0.5
Lift, drag, and thrust are all aerodynamic properties that act on a rocket launch.	57.1	57.1	0.5

<sup>a</sup>Survey was conducted in a multiple-choice format in which students had three possible choices to choose from.

<sup>b</sup>Assessments were conducted with seven students and statistically compared using a student's t-test.

<sup>c</sup>The authors acknowledge that science is a creative process that can be done in several ways, however, students were asked to select from a series of multiple choices the most logical arrangement of scientific method components.

We further explored whether this interest in a science career was specific to health-related fields such as medicine (Fig. 2B), as that can be a common career goal for many students interested in science. However, we did not see a significant ( $p \leq 0.09$ ) shift in those students interested in medicine. When asked what careers the students were interested in, many of the responses included engineering, marine biology, and environmental conservation. While these surveys only provide a transient snap-shot into the interests of these students the results were encouraging that even after one week of being engaged in science-related activities we can potentially spark student interest in science and learning. To address the long-term impacts of summer camps, follow-up surveys online can be used to assess whether changes have occurred in the students' viewpoints three months or even a year after camp. However, in rural areas such as the Exuma Cays where many of the students do not have an online presence or access to computers, such longitudinal tracking can be difficult and may require a continued collaboration with local schools, government officials, and nonprofit organizations such as BME/YBMS.



**Figure 2.** Students' view points regarding their future careers in science and medicine. A student t-test was used to statistically compare the responses in the pre- and post-camp surveys.

## Conclusion

As the pace of scientific discovery and technological breakthroughs continues to surge ahead, the need to build a scientifically literate society that can understand and become engaged with these new advances is critical (Laugksch, 2000; Searce, 2007). Addressing these issues requires multi-pronged approaches that are malleable to fit the needs of the target communities. For those rural areas that may have limited access to institutes of higher

learning or science centers, short-term science camps can serve as low-cost means to bring the relevant scientific information to these remote communities. Here, we described the educational and logistical processes associated with organizing and implementing a summer science camp in a rural international community in the Exuma Cays, Bahamas and present evidence that short-term international camps can improve the student and community awareness of global scientific issues. Although this pilot camp was limited in terms of the number of students, the results regarding the perceptions and knowledge gains of international students indicate that short-term camps do promote scientific literacy and have an impact on motivating students to actively participate in science learning activities.

The spark to learn, however, is only one component to building a scientific literate community. These short-term programs need to be followed with longer-term opportunities for the students to maintain their interest levels, as length of stay in educational programs has been shown to have a significant impact on long-term attitudes and knowledge retention of scientific issues (Shepard and Speelman, 1985; Dettmann-Easler and Pease, 1999). It is not enough to simply ignite their interest in science, but it is essential to foster that enthusiasm with additional activities such as after school programs, educational videos, or additional residential science camps. The Nassau-based YBMS has developed and implemented after school programs for young Bahamians, yet those efforts have been concentrated in more urban areas. Use of free distance education programs such as podcasts, videos, or digital learning objects (Bratina et al., 2002) may serve as means to actively engage rural communities, both international and domestic, in scientific activities throughout the student's academic careers. By helping students and their communities become more scientifically literate we can continue to inspire them to be active citizens concerned about, and caring for, the natural world around them.

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