An Earth Hazards Camp to Encourage Minority Participation in the Geosciences

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ABSTRACT
Summer camps have proven to be effective tools to engage students in the geosciences. Findings from this study highlight perceptions and experiences of middle school students from predominantly African American school districts in Mississippi who attended a 3-d residence camp focused on increasing interest in the geosciences through an earth hazards theme. The 2013 summer camp was structured to emphasize three subject areas: geology, hydrology, and meteorology. Nine middle school students (seven males and two females) attended the camp developed and held at Mississippi State University. Students' pre- and postcamp understanding about geoscience processes and interest in and knowledge about geoscience careers were measured to evaluate the camp's success. Overall interest in geosciences increased after completing the program. Among the three subject areas emphasized in this camp, students gained more knowledge about geology than about the other two areas (hydrology and meteorology). Results indicate that hands-on and experiential learning methods, especially those held indoors or with optimal conditions outdoors, were most successful at stimulating interest. © *2017 National Association of Geoscience Teachers*. [DOI: 10.5408/16-192.1]

Key words: interest in geoscience, career knowledge, informal education, underrepresented populations, minority students

PURPOSE
Among all science, technology, engineering, and mathematics (STEM) fields, geosciences is among the least ethnically diverse (Huntoon and Lane, 2007; Stokes et al., 2015). Nationally, the number of geoscience degrees (with the exception of meteorology degrees) experienced a decline from 1989 to 2007 (National Science Board, 2010). This decline in majors and lack of participation among minorities coincide with a trend toward a geoscience workforce that is increasingly within 15 years of retirement (Perkins, 2011). Combined with an increasing minority population, these events present both a challenge and an opportunity to recruit majors into geoscience fields. Primary and secondary goals of the National Science Foundation's (NSF's) Opportunities for Enhancing Diversity in the Geosciences (OEDG) program are to increase participation in geoscience majors and careers by members of underrepresented groups and to increase the perceptions among diverse populations that the geosciences are relevant (Karsten, 2013). These goals were shared by the Earth Hazards Camp discussed here. There are a number of ways in which students enter or become interested in the geosciences. Levine et al. (2007) confirmed many factors recognized in other STEM fields as contributing to the geoscience pipeline. From other STEM research, the authors confirmed that extracurricular activities, engaging geoscience courses, and geoscience awareness foster high school or middle school students to eventually participate in the geosciences. They added outdoor experiences as a factor specific to the geosciences.

The Earth Hazards Camp attempted to increase interest in the geosciences through a hazards theme. We did this for two reasons. First, preliminary data collected by some of the authors indicated that the extremes of weather and geology (such as tornadoes, hurricanes, earthquakes, and volcanoes) were the topics most favored by a sample of 443 Mississippi middle school students (Sherman-Morris et al., 2012a). Second, hazards are a way to make a connection between Earth Science and society for many students, including minority students. Others have helped increase diversity in the field by showing people that the geosciences affect them and can be applied to relevant societal issues (Huntoon and Lane, 2007). Many individuals from underrepresented groups choose careers and majors from which they believe they can contribute to their community and society (Fields, 1998). Race, ethnicity, and social inequality contribute to social vulnerability to hazards (Cutter et al., 2003), and others have acknowledged the influence of this connection for generating interest in the field. For instance, Anderson (2008) noted the potentially close relationship between environmental justice and disaster research and the rise in interest in vulnerability issues by the African American community following Hurricane Katrina.

BACKGROUND
Summer camps provide a nontraditional, informal science learning environment for students. The value of informal learning is well established (McComas, 1996, 2006; Wandersee and Clary, 2006), and even students at the K–12 level engage in science learning in informal environments more often than within traditional classrooms (Falk and Dierking, 2002). Informal science learning can engage

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citizens in global problems (Roy and Doss, 2007), provide environmental context and land ethic (McLaughlin, 2005), and reach students who are having problems understanding subject matter, providing holistic experiences that are retained (Bernstein, 2004).

In addition to their effectiveness as informal learning environments, summer camps can be used to produce affective changes in students and interest students in future STEM careers and majors. A summer program proved successful at recruiting Hispanic high school students in the geosciences (Miller et al., 2007), while another summer program was effective at increasing the interest of high school students in engineering disciplines (Yilmaz et al., 2010). Attitudinal changes about computing were the strongest among females and African American students attending a computing camp at a large Georgia university (Ericson and McKlin, 2012). Following a 1-week geoscience workshop in California that included hands-on and computer labs, as well as short field trips, student participants rated their knowledge of both geoscience content and geoscience careers higher at the workshop's conclusion (Sedlock and Metzger, 2007). Similar increases in geoscience interest and career awareness resulted from summer programs in Texas for high school students (Carrick et al., 2016; Houser et al., 2015). Within Mississippi, physical science summer camps successfully targeted upper elementary and middle school students (McKone, 2010). The informal science opportunities provided in summer camps (e.g., experiences and field trips) also proved effective at retaining underrepresented populations within STEM majors once they are in college. Extracurricular experiences are among the most important factors for minority student retention (Bembry et al., 1998), and these extracurricular experiences were identified as an important student factor for attracting and retaining minority students in the geoscience career pipeline (Levine et al., 2007).

Finally, summer camps have been used to introduce middle school students to a college campus (Morris et al., 2012) and help students see themselves attending someday. Providing students access to role models during a summer or afterschool experience in the geosciences accomplishes a similar goal. Lack of role models is known to be a barrier to participation in the geosciences (Levine et al., 2007). Exposure during these experiences has been used to counter this barrier to participation. For example, diverse students and faculty led a summer program in order to provide access to role models (Carrick et al., 2016). Female high school students were also recruited to serve as mentors in an afterschool and summer science program for 4th- and 5th-grade girls (Tyler-Wood et al., 2012).

One issue raised in past work on increasing diversity in the geosciences is that even though outdoor experiences or a love of the outdoors often provide motivation for entering the geosciences (Levine et al., 2007) outdoor experiences may be less attractive to minority students or teachers than to Caucasians (Whitney et al., 2005; Sherman-Morris et al., 2012b). Because of this attitude, as well as to avoid discomfort from the summer heat, numerous activities were held indoors. We expected that the relevant subject matter, combined with a mixture of indoor and outdoor activities, would help make this summer camp successful at attracting students from underrepresented groups and increasing their interest level in the geosciences. We next provide a discussion of our camp and its outcomes for others interested in implementing similar programs.

SETTING AND TARGET POPULATION

The camp was located on the Mississippi State University (MSU) campus, which is a land-grant institution. MSU has a diverse student population of 20,000+ representing every state and more than 75 countries. Its African American enrollment of approximately 20% is the highest of the universities in the Southeastern Conference (based on 2014 data). It is also the home to the Howell Observatory, the Institute for Humanities, the High Performance Computing Collaboratory, the Center for Educational Partnerships, and many other research institutes.

The summer camp targeted students in East Central Mississippi, where transportation to the camp would be less of an issue for parents due to proximity. The camp was advertised on the university website, and middle school students from around the state were able to apply. An announcement was sent via email to members of the Mississippi Science Teachers Association. We also provided information about the camp to teachers who had been involved with professional development activities on campus. This provided the most useful method to attract participants. One teacher asked whether information could be sent to her superintendent so that information about the camp could be more widely distributed. Once his permission was obtained, this teacher distributed flyers to the other science teachers.

Students who applied to attend the camp were required to submit a letter of recommendation from one of their teachers. The application process allowed us to understand the demographics of the students and gave us a means for selecting students to participate if interest exceeded the camp's capacity of 15 students. In all, 9 students applied, were accepted, and attended the camp. The group included one Caucasian female, one African American female, one Caucasian male, and six African American males. Six of the students qualified for either free or reduced-price meals. The population included four students who were going into 8th grade and five who were entering 7th grade at the end of summer 2013. Two students came from a location approximately 2 h away, two came from more than 4 h away, and the remaining students lived within an hour's drive. Seven of the students came from schools with African American enrollments of greater than 90%.

CAMP STRUCTURE

The 3-d camp was held in June 2013. Students arrived Monday evening and checked into the dormitory. As part of the check-in process, each student completed a pretest survey with questions about both geoscience content understanding and perception of careers and majors, while parents completed other necessary paperwork. Dormitory policy required one chaperone be provided for every eight students. Therefore, two camp counselors, one male and one female, were hired to accompany the students at all times. The female counselor was African American; a Hispanic female graduate assistant was also hired to help with the activities. Later in the first evening, the camp counselors escorted the students to the geoscience building for an icebreaker activity with pizza and a word-association game in which students had to guess the hazard based on key words. Part of a video about space was played, but students preferred to continue with games and came up with another hazards-related word game on the spot. Quiet time began at 10:00 PM each night, and students were given just a short amount of time between nightly activities and quiet time to minimize the effects of too much unstructured time.

Each day, students were escorted to breakfast at 8:00 AM and then to the geoscience building for activities. These activities covered geoscience topics in geology, hydrology, and meteorology, incorporating a hazards theme where possible. The amount of time spent engaging with geoscience content (as opposed to recreation, meals, etc.) totaled about 24 h, spread a bit unevenly throughout the camp. See Table I for a list of each of the activities and a brief description. A complete schedule is available in the online journal and at http://dx.doi.org/10.5408/16-192s1. In addition to university faculty, graduate students from the NSF-funded Graduate K–12 Initiating New Science Partnerships in Rural Education (INSPIRE) program housed at MSU led several content activities that they had prepared to implement in local area schools and were aligned to Mississippi state science standards, which are based on the 1996 U.S. National Science Education Standards (National Research Council, 1996).

In addition to the geoscience activities, students were provided other opportunities to explore the university setting in order to help them become familiar with the campus and envision themselves as future students. On the first day, students received a tour of campus from an undergraduate tour guide coordinated with the university welcome center. Students went to a movie theater on the second night as a recreational activity, and on the third night, they visited the campus observatory. While at the observatory, students were able to view the sun through a telescope just before sunset and then see Saturn once it became dark. Each afternoon, the students were given about an hour to use the campus recreation center. On the last day (Thursday), students completed the posttest content and perceptions survey, received a T-shirt and certificate of participation, and were released to their parents for a 5:00 PM checkout.

EVALUATION

Two methods were used to evaluate camp success. First, the nine 7th- and 8th-grade students (78% African American males, 56% rising 7th-grade students) completed a pre- and posttest consisting of three parts that aimed to assess their interest and knowledge about the geosciences, understanding about meteorology, geology, and hydrology, and self-efficacy in responding to three short-answer or drawing questions. Second, a research associate attended about two-thirds of the camp activities to make observations. The research associate was a qualified observer as a former K–12 teacher with a graduate degree in the geosciences and was trained by the external evaluator (McNeal) in this project. He was an unbiased observer who did not participate in the development of the project materials or implementation of activities and is not a coauthor of the manuscript. He also attended the lunch periods and used them as a time to discuss the camp with the students.

Geoscience Content Understanding and Perceptions Pre- and Postsurvey

The first part of the survey included two questions about ethnicity and gender. It also asked students what grade they would be entering in August. Part 2 asked students to respond to nine Likert-type statements (coded 0 = disagree strongly to 4 = agree strongly) each about geosciences and biology (Table II). This included statements about interest in both subjects, perceptions about majors in geosciences and biology, and statements regarding geoscience and biology careers. Biology questions were included on the survey for two reasons. Previous research (Sherman-Morris et al., 2013) indicated that a sample of science teachers expressed a significantly lower level of knowledge about what geoscientists do compared to what biologists do. The difference between the two subjects was greater among teachers who identified as African American, whose perceived knowledge of biology careers was greater than that of white respondents but whose knowledge of geoscience careers was lower than that of white respondents. The second reason was that although the camp had a broad theme, none of the activities were specifically designed to cover biologic information. Therefore, the biology questions on the posttest could serve as a control to detect spurious pre- to posttest increases.

In the last section of the pre- and posttest survey, students answered an open-ended question, in which they were asked to make drawings about processes in each of the geoscience content areas. These were scored using two separate grading rubrics. For each subject area, students were asked to produce a drawing illustrating a concept and then rate their confidence level in the accuracy of the drawing, as well as their knowledge of hydrology, geology, and meteorology careers (separately). Confidence questions used a Likert-type response (0 = strongly disagree and 4 = strongly agree). For the hydrology section, the pre- and posttests required students to "use a drawing, text, and arrows to explain how a single water molecule might move between the parts of the Earth that contain air, water, life, and soil (e.g., the water cycle). Please mention how pollution can affect the water molecule." For geology, the question instructed students to "use a drawing, text, and arrows to explain the different types of Earth plate boundaries, and what occurs at each type of boundary (e.g., global plate tectonic theory). In each plate boundary type, identify the potential geologic hazards that are present." Finally, in meteorology, the question asked students to "use a drawing, text, and arrows to show a weather map that displays as many meteorological features as possible." Each drawing was scored from 0 to 5 first according to its correct use and illustration of concepts and then according to the number of references to representative terms, relationships, and systems following a methodology similar to that of McNeal et al. (2014) (Table III). Two graders scored approximately 10% of the pre- and postassessments independently and then compared scores. Discussions of any inconsistencies between scores were conducted until 100% consensus was achieved between graders of the final score. This assisted in quality control and trustworthiness in the scored products and informed the primary grader in the assessment of the remaining products to ensure consistency in the scoring of all products. The primary grader sought consultation from the secondary grader throughout the scoring process, in

TABLE I: Synopsis of geoscience-related activities performed during the camp, including evaluation comments where available. The full schedule is available in the online journal and at http://dx.doi.org/10.5408/16-192s1.

Activity (duration in hours)	Description	Research Associate Observations
Day 1 Geoscience Activities		
Weather forecasting (0.5)	Students were guided through online weather imagery and forecast graphics that meteorologists may use to make a forecast.	Activity had computer issues, had too little introduction, and presented above grade level.
Geology trivia—How much do you know? (0.5)	Using an interactive classroom response (clicker) system, students were queried on hazards. After each question, bar graphs revealed how the group voted, and group discussions corrected misconceptions and/or expanded each question's content.	Activity had an energetic and interactive instructor and age-appropriate language. Use of clickers allowed anonymous participation (reducing embarrassment and increasing engagement).
Oil spill cleanup (0.5)	Part 1: Using clear tubs, colored water, and vegetable oil mixed with cocoa powder, students created a model of an oil spill environment. They then used that model to experiment with different materials to determine possible options for cleaning the contamination. Part 2: Students experimented with water-and-oil interactions with antacids (using a colored water-and-oil mixture and different sizes of tablets: whole, halved, or crushed) to visualize the difference between hydrophobic and hydrophilic components of dispersants.	Hands-on participation generated high energy and enthusiasm. Smooth and expeditious transitions. Students participated in initial demonstrations, giving them ownership.
Spray bottle erosion (0.5)	In the spray bottle erosion pan activity, students constructed a hillside using dirt, sand, and other materials in a paint pan and sprayed the slope with water to determine how quickly, or under what conditions, it would fail.	
Soils field investigation (1.5)	Students participated in a field excursion led by a professor of soil science. The group investigated soils and various plants within the university's South Farm and sampled soils from both the side and the top of a natural levee. A soil separation activity later revealed different compositions of the samples.	Students appeared interested, but unfamiliar surroundings were a distraction. A few were reluctant to walk in grass, fearing insects and reptiles; timing after lunch allowed heat to be a factor, because the activity involved an extended walk.
Geocaching (1.5)	Students were divided into two groups and provided with a global positioning system (GPS) unit. Hazards-related clues were prepared and hidden at four locations. Students had to use the GPS unit to locate and solve the clues.	Some students were noticeably interested. Activity had insufficient introduction and required extended walking immediately following soil activity. Students visibly dragging due to heat.
Soil separation lab activity (0.25)	When back at the classroom building, students filled a glass jar with soil and water and shook the bottle so that the soil components could separate out. The bottle was observed over the 3 d.	
Make a barometer (0.25)	A balloon was stretched over the mouth of a glass jar. A straw with a toothpick glued to the balloon indicated changes in pressure. Students checked their barometers at different times throughout the camp. (http://www.weatherwizkids.com/experiments-barometer-pressure.htm)	
Cloud in a bottle (0.25)	A plastic water bottle had a few drops of water in it, and a Fizz Keeper was used to make a cloud. The Fizz Keeper increases the atmospheric pressure inside the bottle; when the trigger is released, the rapid lowering in pressure cools the air and creates the cloud. (http://eo.ucar.edu/workshops/NSTA2011/images/Cloud_in_Bottle.pdf)	

TABLE I: continued.

Activity (duration in hours)	Description	Research Associate Observations
Day 2 Geoscience Activities		
Seasons activity (0.25)	Students were organized into a circle and "revolved" around the "sun" standing in the middle. They had to keep their arms and torsos oriented toward Polaris as they did so. To add to the fun, once students identified each of the seasons, they tried to rotate around their own axis and revolve at the same time.	
Fossils and the geoscience museum (0.5)	Following the fossil-collecting field excursion, students tried to match their fossils with those displayed in the campus Dunn-Seiler Museum. Students also investigated fossils representative of different geologic times, including the Pleistocene. They also probed the scale of geologic time.	
Make it rain activity (0.25)	The purpose of the activity was to simulate the temperature differences in the atmosphere and the process by which condensation and rain occur. The activity used a jar filled with hot water and a dish of ice cubes on top. (http://www.weatherwizkids.com/experiments-make-rain.htm)	
Earthquake in a bucket (0.5)	The earthquake in a bucket activity examined the intersection of Earth systems with the human environment. First, students built popsicle-stick structures in or on top of a bucket of sand. Then, the bucket was shaken to demonstrate how differently built structures might fare when subjected to Earth movements.	Engaging and hands-on. Students enjoyed creating the stick structures and enjoyed expressing their creativity. Little introduction or explanation; end goal unclear. Students did not receive feedback as to why a structure survived.
Volcanic eruption/lava viscosity lab (1.0)	Activity leaders set up a volcano to highlight the dangers of pyroclastic flows and the debris that gets launched into the air during a volcanic eruption. The viscosity lab consisted of a race of five liquids on a smooth piece of foil-coated cardboard: mayonnaise, ketchup, mustard, yogurt, and honey. The students had to hypothesize which would be the most viscous.	Volcano did not erupt, resulting in students standing outside with nothing to see. Viscosity demonstration was unenthusiastically introduced, and students lost interest quickly.
Volcanoes and plate tectonics (1.0)	Plate tectonic boundaries and associated forces were reviewed with an interactive "cookie tectonics" activity. Students next participated in curiosity-starter readings (period Krakatoa news articles) and sensory priming activities with volcanoes (sounds, smells, and Pop Rocks candy) (Clary and Wandersee, 2011) before investigating volcanic events, and volcano locations.	
GIS activity (1.0)	Students analyzed ArcGIS data of wildfire occurrences in Mississippi compared to road density to determine whether the occurrence of wildfires increases in areas with high road density.	Computer issues caused some to fall too far behind to participate. Presented above grade level with lack of preparation.
Meteorites and craters (1.0)	To set up this activity, the leader sprinkled cocoa powder and flour onto paint pans or baking pans placed on the floor. Students viewed how speed and angle of impact affected the shape of a crater by throwing a marble "meteorite" at the pans.	Presentation was rushed and included little introduction; little enthusiasm.
Storm chasing presentation (0.5)	A graduate student who had recently participated in a storm chasing field course gave a presentation about her experience.	Students were initially engaged but lost interest quickly. Material focused on Oklahoma and chaser stories (not relevant).
Build a tornado (0.5)	Tornadoes were modeled using a piece of foam core as a base, a plastic plant saucer and transparency paper as sides, a computer fan for exhaust, and dry ice in a dish of water to provide the visible updraft. (http://eo.ucar.edu/webweather/tornact3.html)	Students given instructions, easy-to-follow diagrams, and readily available supplies. They were visibly interested in activity and showed excitement and pride when their tornado functioned properly.

TABLE I: continued.

Activity (duration in hours)	Description	Research Associate Observations
MSU Howell Observatory (2.0)	Students arrived at the observatory on campus just before sunset. They were first able to observe the sun and sunspots through a filtered telescope. After waiting for darkness, an astronomy professor highlighted various points of interest in the night sky using a laser pointer. Following this, the students viewed the sky, including Saturn and its rings, through a telescope.	
Day 3 Geoscience Activities		
Lightning activity (0.5)	Students discussed how lightning is generated in a thunderstorm and lightning safety precautions before participating in demonstrations using a Van de Graaff generator. The demonstration used various objects such as lightbulbs, grounder wand, and students' hair.	Easy-to-understand graphics, age-appropriate explanations, and student volunteers were used. Demonstration was hard to see. Allowing students to get up and move around would have improved their experience.
Making a weather show (1.0)	Students recorded themselves doing a "weather show" with simple graphics in MSU's broadcast meteorology studio.	Outstanding introduction and description of career skills and educational background. Giving students opportunity to present on-camera was a good confidence builder.
Tornado activity (1.0)	Students compared the Fujita scale to images of tornado damage to demonstrate the level of damage used to determine the scale before simulating a tornado in a bottle. This demonstrated the importance of atmospheric circulation to the formation and strength of tornadoes.	Activity was well received and gave students the opportunity to create something of their own.
Aim a hurricane (0.5)	Students played with an online game in which they were able to control winds and the movement of a hurricane by moving pressure systems. (http://www.nhc.noaa.gov/outreach/games/movncane.htm)	Activity was above age level and lacked detailed introduction.
Weather balloon launch (1.5)	Students were taken to an agricultural area near MSU, where they assisted in the launching of a weather balloon with attached radiosonde (instrument measuring air temperature, moisture, wind direction, and speed). Before the launch, the process was described and students were able to handle the balloon material and equipment.	Activity was very well received. Process described earlier in detail, giving students a reference when they were able to handle the balloon in the field.
Water-quality testing (1.0)	Students were taken to Chadwick Lake, a stocked recreational lake adjacent to the campus recreation center, to test the water quality. Using a LaMotte Green water monitoring kit, students collected a water sample and performed tests for temperature, pH, turbidity, nitrates, and phosphates.	Students seemed to enjoy performing experiments. Explanation of purpose was not sufficient.
Careers presentation (0.25)	Fellows in the department's NSF-funded graduate K–12 program made annual funny, but educational, videos about careers in their STEM field. Two of the geoscience videos about geology and meteorology careers were played for the students in the camp.	

which both graders scored additional assessments, beyond the initial 10%, as deemed necessary.

Classroom Observations and Focus Group Sessions

During each of the lunch periods, an informal focus group discussion was conducted with all nine students. The focus group discussions were led by a research associate who had been present during most of the summer camp but who did not have a role in leading any activities. The camp leaders were not present for the focus groups. The research associate also attended about two-thirds of the activities in Table I and provided a report of his classroom observations as part of the evaluation procedures.

RESULTS

Due to small sample size and the lack of normality in the dataset, a Wilcoxon signed rank test was conducted on all pre- and posttest student data. Likert-type responses were treated as interval level data, as suggested in Trochim (2005).

TABLE II: Pre- and posttest questions measuring attitudes toward the geosciences. Attitudes toward biology were measured for comparison and as a control.

Q1: I am interested in the geosciences (biology).
Q2: I know what classes I need to take to become a geoscientist (biologist).
Q3: A major in geosciences (biology) requires too many math classes.
Q4: I can handle the classwork needed to become a geoscientist (biologist).
Q5: I think it would be hard to find a job in the geosciences (biology).
Q6: I don't know much about geosciences (biology) careers.
Q7: Most geoscientists (biologists) make good money.
Q8: I think I know what geoscientists (biologists) do at work.
Q9: I would be proud to be a geoscientist (biologist).

Geoscience Content and Perceptions Pre- and Postsurvey

Student average scores, standard deviations, and gains are shown in Table IV. Students showed the biggest increases in their geoscience career knowledge and interest with gains that were significant or approaching significance in their responses to "I am interested in the geosciences" (gain = 0.43, $p = 0.083$), "I know what classes I need to take to become a geoscientist" (gain = 1.01, $p = 0.034$), "I don't know much about geoscience careers" (gain = −1.22, $p = 0.11$), and "I think I know what geoscientists do at work" (gain = 0.58, $p = 0.102$). After recoding responses to negatively worded statements, reliability analysis was performed to determine whether the set of geoscience perception questions could be combined. Values for Cronbach's alpha were sufficiently high (0.83 for the pretest and 0.76 for the posttest) to do so. The average of the combined variable geoscience perception increased from 2.60 to 2.97 between pre- and posttest, a difference that was statistically significant (gain = 0.37, $p = 0.043$). Students' overall biology career knowledge did not increase significantly or overall; however, their agreement with the statement that "I would be proud to be a biologist" decreased to a level that approached significance (−0.58, $p = 0.059$). As with the geoscience statements, Cronbach's alpha was sufficient to combine the biology statements into single pre- and posttest variables (0.77 for the pretest and 0.90 for the posttest).

Student average scores, standard deviations, and gains to the content questions are shown in Table V. Raw scores increased in every measure from pre- to posttest except for the meteorology drawing. Students showed an increase in their knowledge of geology, measured by a significant increase in their use of representative geology terms, relationships, and systems ($p = 0.042$) and a nearly significant gain in their use and illustration of geology concepts ($p = 0.059$). Student confidence levels in all three areas improved (pretest = 1.74, posttest = 2.90), with a significant ($p = 0.026$) gain in confidence in the accuracy of the geology drawing and nearly significant gains in hydrology and geology career confidence ($p = 0.084$ and $p = 0.059$).

TABLE III: Rubric used to score geology, hydrology, and meteorology drawings.

Conceptual Knowledge
0: Simple restating of the question.
1: Statement of a single correct fact.
2: Statement of multiple correct facts.
3: A. Statement of multiple correct facts, with a single connection between facts. OR B. Statement of multiple correct facts, with multiple connections between facts. Misconceptions are equal to or dominate over scientific conceptions.
4: Statement of multiple facts, with multiple connections between facts. Misconception or misconceptions are present, but scientific conceptions dominate.
5: Statement of multiple facts, with multiple connections between facts. Misconceptions are not present within a story that is cohesive; misconceptions about concepts outside of the core message may be present.
Systems Knowledge Scored according to number of references of representative terms, relationships, and systems.

Focus Group Discussion

A more qualitative evaluation of effectiveness was gained through focus group discussions held during the lunch hour. During focus group sessions, it became clear that the students preferred activities that consisted of hands-on and experiential learning over those that were more lecture, computer, or outdoor based. For example, when asked "which activities they liked best," one student replied, "The ones where we actually do the experiment helps us learn." Another student stated, "I like doing, rather than sitting. I learn by doing." Some students went on to describe their desire to try the hands-on activities at home and to describe them to their teachers for classroom use, showing their appreciation and enthusiasm about these activities in particular. As part of the focus group discussion, students were asked whether "they would come back next year" and there was an immediate and 100% positive response, indicating that students enjoyed the camp and their experiences.

Comments about the specific activities also helped to indicate which activities were liked. Students remarked, "I saw the rings of Saturn!" and "The tornado-weather balloon-oil spill-geology-erosion-weather studio was great!" One student said that the geocaching was "fun" but another said it was "boring and way too far to walk." Similarly, a student said the soil activity was "interesting to see that there are different soils all around us," while others noted that it was "too hot," that they did not like bugs and tall grass, and that "We had to walk forever." The geographic information systems (GIS) activity prompted several negative comments. These included that it was "kinda cool, but I didn't really understand it at all" and "My computer didn't work, so I quit watching." Another student also indicated not understanding what the instructor was talking about.

Classroom Observations

The classroom observations conducted at the camp yielded specific, qualitative feedback on the activities and the

TABLE IV: Pre- and posttest (0–4 scale) surveys showing change in interest in and understanding of the geosciences. Biology scores are provided for comparison purposes.

Question[2]	Pretest Mean (SD)	Posttest Mean (SD)	Pre- to Posttest Gain	*p* value
GEO Q1 (Interested in geo)	3.00 (0.50)	3.43 (0.53)	0.43	0.083*
GEO Q2 (Know what classes to take)	1.56 (0.73)	2.57 (0.53)	1.01	0.034**
GEO Q3 (Too much math)[1]	1.89 (0.60)	1.64 (1.02)	0.25	0.450
GEO Q4 (Can handle geo classwork)	3.22 (0.67)	3.14 (0.69)	−0.08	0.317
GEO Q5 (Hard to find geo job)[1]	1.44 (0.73)	1.33 (0.51)	−0.11	1.000
GEO Q6 (Don't know much about careers)**	2.22 (1.30)	1.00 (0.58)	−1.22	0.109
GEO Q7 (Geo make good money)	2.33 (0.50)	2.50 (0.84)	0.17	0.564
GEO Q8 (Know what geo do at work)	2.56 (0.53)	3.14 (0.69)	0.58	0.102
GEO Q9 (Proud to be geo)	3.44 (0.52)	3.43 (0.79)	−0.01	0.564
BIO Q1 (Interested in bio)	2.89 (0.33)	2.71 (0.76)	−0.72	0.317
BIO Q2 (Know what classes to take)	1.89 (0.78)	2.29 (0.49)	0.40	0.180
BIO Q3 (Too much math)[1]	1.78 (0.44)	1.71 (0.95)	0.07	1.000
BIO Q4 (Can handle bio classwork)	3.22 (0.44)	3.00 (0.82)	−0.22	0.414
BIO Q5 (Hard to find bio job)[1]	1.44 (0.53)	1.57 (0.53)	−0.13	0.157
BIO Q6 (Don't know much about bio careers)[1]	1.99 (1.05)	1.86 (1.35)	0.13	0.317
BIO Q7 (Bio make good money)	2.44 (0.73)	2.29 (0.49)	−0.15	0.157
BIO Q8 (Know what bio do at work)	2.22 (0.83)	2.43 (0.98)	0.11	0.414
BIO Q9 (Proud to be bio)	3.44 (0.53)	2.86 (0.69)	−0.58	0.059*

*Approaching significance.
**Significance at 0.05 level.
[1]Negatively worded.
[2]Geo = geosciences or geoscientist; bio = biology or biologist.

way they were presented. This feedback allowed us to identify some common factors in what worked well and what could be improved for next time. The observations, although provided about individual activities (Table I), grouped around three general areas; qualities of the instruction, type of activity, and scheduling decisions.

Regarding the instruction, activities that generated the most positive observations were those for which the instruction was appropriate to grade level, the activity was adequately described, and the instructor was enthusiastic about the material but did not rush through it. Several meteorology activities were noted to have been presented

TABLE V: Pre- and posttest drawing scores (0–5 scale for concepts, number of references for systems, and 0–4 scale for confidence) in hydrology, geology, and meteorology.

Question[1]	Pretest Mean (SD)	Posttest Mean (SD)	Pre- to Posttest Gain	*p* value
Hydro draw concepts	2.00 (1.22)	2.14 (1.57)	0.14	0.914
Hydro draw systems	3.56 (2.55)	4.00 (3.11)	0.44	0.786
Hydro accuracy confidence	2.78 (0.67)	3.00 (1.00)	0.22	0.655
Hydro career confidence	1.44 (1.01)	2.57 (0.53)	1.13	0.084*
Geo draw concepts	1.11 (1.17)	2.00 (1.15)	0.89	0.059*
Geo draw systems	2.78 (3.07)	4.71 (2.98)	1.93	0.042**
Geo accuracy confidence	1.33 (1.22)	3.29 (0.76)	1.96	0.026**
Geo career confidence	1.25 (0.88)	3.00 (0.82)	1.75	0.059*
Met draw concepts	1.44 (0.88)	1.14 (0.90)	−0.30	0.157
Met draw systems	3.44 (2.53)	2.57 (1.40)	−0.87	0.336
Met accuracy confidence	1.89 (1.67)	2.71 (0.76)	0.82	0.129
Met career confidence	1.75 (1.16)	2.86 (0.90)	0.81	0.141

*Approaching significance.
**Significance at 0.05 level.
[1]Hydro = hydrology; geo = geology; met = meteorology.

above grade level, such as weather forecasting and aim a hurricane. Other meteorology activities were successful. For example, as part of the weather balloon launch, students listened to a description of the launch process and were able to handle the balloon and equipment. This provided them a reference when they witnessed the launch. Positive observations about the tornado building activity also included clear instructions and easy-to-follow diagrams. The most commonly noted area for improvement in the geology activities was the need for greater introduction or a more enthusiastic introduction. Students enjoyed all the geology activities, with the possible exception of a demonstration about volcanoes and viscosity; however, when presenters rushed through or did not introduce an activity sufficiently, it affected what they were able to gain from the activity. For example, the research associate's observation indicated the volcano activity was not introduced enthusiastically, and the slow pace of the lava "flows" down the board caused some students to lose interest. A geology trivia activity was highly successful, reportedly due to an enthusiastic instructor, age-appropriate language, and the use of clickers, which gave the students something to do but also minimized embarrassment for choosing an incorrect response. A later presentation about geologic time by the same instructor also kept students highly engaged. This too incorporated age-appropriate language and imagery and connected the geology information to the students' perspective and surroundings. The instructor on these highly rated geology activities was a professor with many years of experience performing research and outreach in geoscience education, as well as some time spent teaching at the middle and high school levels.

Closely related to the instruction is the type of activity. Most of the geology activities were hands-on, which led to positive feedback. Students enjoyed creating the stick structures for the earthquake activity. The oil spill and spray bottle erosion activities also generated high levels of enthusiasm in the students. The volcano activity discussed earlier was an exception. The demonstration was not active for the students and may be a cause for their loss of interest. Hands-on meteorology activities also were well received. Examples included two tornado activities, one in which students created a simple "tornado" in a bottle and another in which they built a tornado that replicated some of the environmental factors responsible for tornadoes. Being able to produce their own tornado in a container they had assembled from readily available supplies generated excitement and pride in the students. Students also enjoyed the ability to record a weather broadcast, and observations indicated this was a confidence-building activity. Multiple activities relying on computers did not work as well. Because they had not been used frequently during the summer, the computers were sluggishly installing updates during the activities. This led to disengagement, because some students were not able to keep up. These activities also tended to be presented above the students' grade level, so it is difficult to isolate which factor may have been more influential. Examples included two of the meteorology activities held in the computer lab, as well as the GIS activity.

Finally, several observations related to scheduling decisions. The research associate believed that the soils activity and the geocaching activity both were negatively affected by their scheduling following lunch. The geocaching activity could only be scheduled in the late afternoon due to a last-minute schedule change, and students were visibly affected by the heat. While it was cloudy and not quite as hot during the soils activity, students were distracted by the unfamiliar outside environment. Several did not want to walk through high grass for fear of insects and snakes. Observations indicated that the students did enjoy performing water-quality experiments at the campus lake, which was also outside during the afternoon. In this case, the students did not have to walk much and were actively performing the experiments. The research associate was not able to attend the fossil collecting activity due to other commitments. Fossil collection was scheduled for first thing in the morning, but without the observations of the research associate, we are unable to make a direct comparison between it and the afternoon activities. The instructor for fossil content noted that students were engaged in collecting and comparing their fossil finds with displayed museum specimens and students' verbal reflections were positive. In addition, other experiences with bringing students to campus for fossil collection have been successful, and there was no evidence from focus group discussions that the summer camp group had any negative impressions about the experience.

IMPLICATIONS

Overall, our results show that the camp was most effective at increasing students' interest and confidence in the geosciences, as well as their knowledge about what courses are needed to major in associated programs. Students acquired the most notable knowledge gains in the geology components of the program. Part of this difference among geoscience subject areas could be linked to the prior experiences of the lead instructors, because the geology instructor had significant experience with the K–12 environment and students. Other possible explanations are that the learning goals, activities, and assessments for the geology curriculum were better aligned than the other two content areas in the project to the pre- and postassessment and/or the geology lessons incorporated more hands-on activities.

Indoor experiential learning ranked more favorably with middle school students when compared to outdoor experiences in the summer heat. However, not all inside activities were favored. Activities that were computer based were not as effective as those that required interacting, building, experimenting, or creating. We learned that with middle school students, hands-on activities must be a central part of the implementation in order to keep students' attention and focus on the content areas. We also learned that outdoor learning in the southern United States requires planning to optimize the comfort of the participating students, such as scheduling outdoor activities in the early morning when temperatures are lower. Our results suggest that while authentic geoscience activities are important (e.g., field excursions), weather and climate conditions can be equally essential to effectively engage the students and optimize their learning and positive attitudes if the activity is designed correctly. Indoor activities that encourage active participation may be best scheduled during early afternoon to counter temperature and afternoon lethargy (Pope, 2016). In addition, outdoor activities that had too much or too little activity were more likely to receive negative comments.

LIMITATIONS

This camp was conducted with a small number of students; therefore, interpretations of the effectiveness results are limited. We did not attract as many students as we could have accommodated. We did not know how many applications to expect and were not sure how much recruiting would be necessary. In retrospect, we should have assumed that interest would not be high in the first year of the program and worked harder to generate interest among teachers at targeted schools with whom we previously worked. However, the camp size is typical for this type of program (e.g., Sedlock and Metzger, 2007). The size was effective for the types of activities that were used, and a larger group would have required additional counselors. Ideally, we would have been able to run the camp multiple years for collection of evaluation data. However, this was not possible. We also did not conduct a survey or interviews to measure long-term impacts. The students who attended the camp have not yet entered college. Therefore, we are unable to determine whether will choose to major in geoscience or STEM fields.

RECOMMENDATIONS FOR GEOSCIENCE CAMP ORGANIZERS

Although organizing and holding a summer camp for middle school students may seem like a daunting task, it is possible and can bring many positive learning outcomes for the students participating in the experience. We provide the following recommendations for those who intend to implement a summer camp at their home organizations:

- Generate interest among science teachers with whom you already have a relationship. They will be more likely to spread the word enthusiastically to their students.
- Inform superintendents and principals about the opportunity. Their permission might be needed to distribute flyers or applications.
- Use an active learning, hands-on approach to classroom activities, because these are the activities that were most highly regarded by our students.
- Have a schedule for the students, which can include structured free time.
- Plan to have sufficient counselors and numerous teaching assistants on staff to supervise, escort, and interact with students.
- Encourage a fun learning experience that not only goes beyond the knowledge-centered lens but also promotes social interactions and relationships.
- Leverage existing programs and campus resources that will help create a fun, informative, and novel learning experience for students. Students may have never been on a college campus before.
- Try to have instructors who have experience working in a K–12 environment in your ranks, or provide more guidance to help instructors develop lessons appropriate for the targeted grade level.
- Include an evaluation program that will help assess your level of success. This should include not only knowledge but also self-efficacy and attitudes. Classroom observations help to provide richer information.
- Plan for a method to measure long-term impacts. This could include information on career or college decisions made by older students or a follow-up survey, if time does not allow tracking through college enrollment decisions.

CONCLUSIONS

The summer camp met its overall goal of increasing the interest in and perceptions about geoscience careers and majors. The average score on the geoscience perceptions measure rose significantly from pre- to posttest. Students also showed an increase in their knowledge of geology and confidence in their accuracy about geology responses. Nearly significant gains were found in confidence about hydrology and geology careers. Classroom observations suggest that the lack of gains in meteorology may have been due in part to material that was not age appropriate and trouble with technology. Observations support future workshops having activities that are hands-on or interactive and scheduling more lively activities inside (and out of the heat) after lunch to counter lethargy. Outdoor activities that were more successful consisted of less walking and more doing. Both lack of movement (e.g., standing around listening) and too much walking led to negative feedback about activities held outdoors. The combined summer heat and walking during outdoor activities even seemed to decrease students' enthusiasm and hinder them from focusing in follow-up classroom activities. Finally, instructors who connected the material to the students at an appropriate age level, with the correct level of introduction, depth, and feedback, had the most effective impact on learning. This observation was supported by the quantitative pre- and posttest results in geology.

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