Effectiveness of Geosciences Exploration Summer Program (GeoX) for Increasing Awareness and Knowledge of Geosciences

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ABSTRACT

Summer research experiences are an increasingly popular means of increasing awareness of, and developing interest in, the geosciences and other science, technology, engineering, and math programs. We describe and report the preliminary results of a 1-wk Geosciences Exploration Summer Program in the College of Geosciences at Texas A&M University to introduce high-school students to opportunities and careers in the geosciences. Short-term indicators in the form of preprogram and postprogram surveys of participants and their parents suggest that there is an increase in participant understanding of geosciences and interest in pursuing a degree in the geosciences. The participants and their parents had relatively limited knowledge of the geosciences at the start of the program, and very few had a friend or acquaintance employed in the geosciences, despite the importance of geosciences to the state economy. Postprogram survey results suggest that the students had an improved and nuanced understanding of the geosciences and the career opportunities within the field. A survey of the parents several months after the program had ended suggests that the parents had greater awareness of the geosciences through conversations with the participants or their own research. Although the influence of the parents on a students' decision to study geoscience is unclear and merits further investigation, it is concluded that future offerings of this and similar programs should engage the parents to ensure that the geosciences are recognized as a potential academic and career path.
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INTRODUCTION

A continuing challenge in science, technology, engineering, and math (STEM) education is the recruitment of underrepresented groups in those fields in the workforce (see Vaidynathan, 1998; Snieder and Spiers, 2002; Mazumdar et al., 2006; Huntoon and Lane, 2007; Hoisch and Bowie, 2010; Sherman-Morris et al., 2013). The geosciences continue to have the weakest diversity record of the STEM disciplines and rank last for African Americans and Hispanics (NSB, 2010). Science and engineering indicators suggest that only 240 bachelor's degrees in the geosciences (out of 73,855 science degrees) were awarded to underrepresented minorities (NSB, 2010). This is consistent with earlier reports that only 3% of geosciences bachelor degrees were awarded to Hispanic Americans and 1% to African Americans, and the graduate rate for underrepresented groups is even lower for advanced master's and doctoral degrees (Drummond, 2004). Although the number of degrees awarded to underrepresented minorities in the "basic" sciences (biology, chemistry, physics, etc.) has increased, the number of geoscience degrees awarded to all students has actually declined, and participation rates by underrepresented minorities have not improved. As noted in the American Geophysical Union's *Diversity Plan* (AGU, 2002), *"racial and ethnic minorities, and persons with disabilities are under-represented as scientists…. [They] can bring insights, perspectives, and talents into our programs…."* Increased participation by these underrepresented groups in college and university, and particularly in the geosciences, depends on innovative and effective recruitment and retention practices. Summer research experiences can help bridge the gap brought about by income, geographic location, and prior exposure to the geosciences (e.g., Miller et al., 2007; Baber et al., 2010).

Exposure of interested high-school students to content and careers in the geosciences has proven to be an effective pipeline for encouraging underrepresented students to enter undergraduate programs (Miller et al., 2007). Across the country, geoscience courses (including earth sciences, human geography, and environmental science and studies) are rarely required in high-school science curricula (see Schmidt, 2013), and only 22% of graduating high-school students in 2005 had taken a geoscience course, compared with 92% having taken a biology course (Gonzales et al., 2009). Before 2009, there were no geoscience requirements for students after middle school in Texas, and classes in earth and space science, environment systems, advanced placement (AP) environmental science, and AP human geography are only available as geoscience-related electives in some schools (Texas Education Agency, 2005). Revisions to the state's "*Recommended High School Graduation Plan*" led to an earth and space science course that was an option for one of the four sciences required for graduation in addition to environmental science and human geography where offered. However, students were also able to take courses in astronomy and aquatic science, which are not necessarily gateways to the geosciences. The lack of geoscience-related courses in high school is compounded by the relatively few teachers with either a geoscience degree or exposure to the geosciences during their undergraduate degree (Levine et al., 2009; McNeal, 2010). Few teachers are able to confidently expose their students to the geosciences directly or indirectly through traditional STEM classes. A 2013 change in the

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Recommended High School Graduation Plan no longer requires four science courses for the minimum and recommended high-school graduation plans, but they remain an option for those students completing a distinguished graduation plan. Few high-school students in Texas take geoscience-related courses at those schools fortunate enough to be able to offer them as science electives.

Despite the economy of Texas being deeply rooted in geological resources onshore and offshore and the susceptibility of the state to severe weather (hurricanes and drought), it has been the experience of the authors that there is a lack of exposure and awareness about the geosciences. The lack of knowledge about the geosciences can lead to a negative perception of the field (O'Connell and Holmes, 2011) and a belief that a geoscience career is not very prestigious or lucrative (Hoisch and Bowie, 2010). Parents encourage their children to go into known and rewarding fields (e.g., medicine, law, service, industry), rather than the geosciences, because they know little or nothing about the field. In this respect, Levine et al. (2007) suggest that undergraduate programs also need to engage adults and parents to ensure the entire family recognizes the geosciences as a potential academic and career path. With ~50% of the geoscience workforce retiring within the next 15 y (Gonzales and Keane, 2009), it is going to be difficult to replace the experienced professionals without an increase in geoscience exposure in high schools across the country. "*The concern is not only in the numbers, but also the ability to facilitate the technical and business requirements of employers in the future*" (Gonzales, 2009; p. 550).

Undergraduate recruitment programs can include (1) research projects and internships that involve high-school seniors (e.g., Cornell, 2006; Riggs et al., 2007), (2) outreach to high schools through teacher education and classroom visits (e.g., Eyles et al., 2006; Pickering et al., 2012; Ellins et al., 2013), and (3) summer recruitment programs (e.g., Miller et al., 2007). Most programs follow the change model from Seymour (2002), in which the development of interest and enthusiasm in science, positive experiences, and learning about science careers can translate into more students pursuing a geosciences degree. With a few recent exceptions in the peer-reviewed literature (Miller et al., 2007; Stokes et al., 2007; Kitts, 2009; Baber et al., 2010; Yu et al., 2011; Hammersley et al., 2013; Maygarden et al., 2012; DeFelice et al., 2014), the review of outreach programs has been limited to descriptions and advice from experienced program developers (e.g., Hood, 1994; Munn et al., 1999; Swim, 1999; DeLooper et al., 2000; Evans et al., 2001; Pelaez and Gonzalez, 2002; Dolan et al., 2004; Halford, 2005; Fakayode et al., 2014). There are few data and objective analyses to determine whether the programs are truly successful in engaging and recruiting students, despite clear evidence of increased participation in the geosciences by underrepresented students through programs at the University of Texas at El Paso (Pathways, Miller et al., 2007) and the University of Texas (GeoFORCE; Eleanour, 2010). These programs have "effectively" increased student awareness and interest in the geosciences, particularly among underrepresented minority groups. Based on relatively qualitative reviews, participating in a short-term science program can have a positive effect on the perceptions and learning achievements of the students (e.g., Schacter and Jo, 2005; Doerschuk et al., 2007; Fields, 2009; Foster and Shiel-Rolle, 2011) if those programs provide supportive, challenging, hands-on research opportunities for students through knowledge and skills development, academic and social integration, and advising (Haller et al., 2010). Results from GeoFORCE (2013) suggest that participation in a recruitment program significantly increases the number of students applying to a college, with 96% of student participating in GeoFORCE attending college, compared with only 42% for students with a similar background and academic preparation in the United States. Results also suggest that 94% of participating students returned to college in their sophomore year and that almost 90% were on track to graduate from college, compared with just 20% with similar academic preparation and backgrounds.

This article describes a Geosciences Exploration Summer Program (GeoX) in the College of Geosciences at Texas A&M University. The purpose of this 1-wk summer outreach program was to (1) increase awareness of the geosciences among high-school students from underrepresented groups (e.g., Baber et al., 2010); (2) highlight career opportunities in the geosciences; (3) expose students to Texas A&M and the college campus experience; (4) expose participants to a cadre of faculty, staff, students, companies (British Petroleum, BP day), and job outlooks; and (5) provide detailed information about the college admission process at Texas A&M University. In addition to a general description of the program, this article examines the results of preprogram and postprogram surveys of the awareness of students and parents of the geosciences and its career opportunities. The surveys not only allowed for an assessment of increased awareness but also provided the opportunity to explore how parental awareness of the geosciences may affect student selection of undergraduate programs.

Program Description

The GeoX camp, held during a 7-d period in 2011, 2012, and 2013 at Texas A&M University, was designed to enhance awareness of the geosciences among high-school students from around the state of Texas. The program was designed by the former director of recruitment (Dr. Sonia Garcia) to (1) introduce talented students, and particularly those within underrepresented groups, to the rewards available for professionals with degrees and careers in geosciences; (2) allow participating students to experience a microcosm of the collegiate and professional experiences of geosciences students; and (3) create a community of learners in geosciences and expose them (early on) to the opportunities in academia, research, and geoscience careers. As described below, students actively participated in a variety of hands-on field and laboratory projects directed by faculty and graduate students from Texas A&M University. The program is modeled in part on successful programs at the University of Texas at El Paso (Pathways; Miller et al., 2007) and the University of Texas (GeoFORCE; Eleanour, 2010) that were designed to increase knowledge of geoscience among underrepresented groups in the state of Texas (Table I). The latter outreach program focuses on rural, border towns and inner-city schools to increase the diversity of students entering the geosciences specifically and in STEM fields in general. The program is a companion to another high-school recruitment program called iGEO (http://igeo.tamu.edu), and to GCamp (http://g-camp.tamu.edu), an outreach and training program for high-school teachers in the state of Texas.

TABLE I: Description of similar initiatives in the State of Texas designed to introduce students and teachers to the geosciences.

Program	Institution	Description	Funding	Participation	Dates
Pathways	University of Texas–El Paso	Increase the number of Hispanic-American students who attain bachelor's, master's, and doctoral degrees in the geosciences and then enter geoscience careers and increase the awareness within the El Paso community of the geosciences as an important and relevant scientific discipline with many career opportunities.	National Science Foundation	20–25 students/y	2003–2013
GeoFORCE	University of Texas	Prepare Texas high-school students to become part of the geosciences workforce by providing public, professional development program for teachers and a summer earth science college preparatory program for high-achieving middle and secondary school students	Government and industry	~600 students/y	2005–present
iGEO	Texas A&M University	Introduce motivated and talented underrepresented high-school juniors and seniors to the geosciences.	Industry	~15 students/y	2012–present
iGIS	Texas A&M University	Introduce motivated and talented high-school juniors and seniors to geographic information science and technology (GIST)	Industry	25 students	2014–present
G-Camp	Texas A&M University	Field camp for 5th- to 12th-grade science teachers designed to provide first-hand experience with the principles of geology in the field, help teachers develop new curriculum and virtual field trips, and make learning fun and exciting out of doors.	Industry	30 teachers/y reaching 110,000 students	2008–present

Audience

Recruitment of potential students was partly completed in collaboration with the Prospective Student Centers and school system administrators throughout the state of Texas. Potential student participants were also identified in collaboration with the University Honors Program, from which College Board Preliminary Scholastic Assessment Test (PSAT) scores were obtained. Specifically, GeoX recruitment involved (1) contacting students and teachers in high schools with large enrollments and a diverse population in Houston, Dallas, San Antonio, and Austin, Texas; (2) attending college career fairs in strategic recruitment areas, such as Bryan, Houston, San Antonio, Corpus Christi, and Dallas, Texas, which are the traditional feeder regions for Texas A&M University; (3) targeting students with math, science, AP science interest, and specifically, those who had completed the PSAT and/or Scholastic Assessment Test (SAT); (4) developing personal networks with high-school counselors and school districts' science facilitators; (5) visiting targeted and nontargeted high schools and presenting information on the college and the GeoX summer opportunities; and (6) targeting students in Texas by buying the college board's PSAT testing results from the previous junior year. GeoX flyers, posters, and online application information were also distributed directly to high-school counselors and principals throughout the state of Texas. Information about the program and student selection was further posted under the College of Geosciences recruitment Web site, through a dedicated GeoX Web page; Facebook; and other social-networking sites under the College of Geosciences.

The summer program was specifically targeted to serve high-school juniors who are starting to consider future career options and the college programs that will best serve those choices. Students were selected through an application process that included the submission of grade point average (GPA), teacher recommendations, and a written statement on the student's interest in science. The applications were made available through the GeoX Web site (http://GeoX.tamu.edu/) and were due mid-April in each year of the program. Applications were evaluated by faculty representatives from each of the participating programs (atmospheric science, environmental programs, geography, geology and geophysics, and oceanography), and were assessed based on GPA, reference letters, and potential interest. The faculty did not use a standard rubric but selected students based on whether they would be eligible for entry into Texas A&M University and whether that student would be successful in their program. For example, students interested in atmospheric science require very different skills and coursework than do students interested in pursuing a degree in geography or the environmental geosciences. The faculty representatives met as a committee to ensure that the students selected for the program were equally distributed among the participating programs. The selection process was completed in early May, and the program began in the first week of June in each year. Funding for the program was provided by private donations from former students and private industry. As a result, there was no fee for the students to attend the summer camp.

Program Activities

Participants selected for the program were invited to stay for one week at a residence hall on the main campus of Texas A&M University to actively participate in field and

TABLE II: Description of the hands-on activities completed by students participating in the Texas A&M University GeoX program.

Activity	Department	Description
Meteorology	Atmospheric science	Launch of a sonde to interpret the vertical structure of the atmosphere
Radar	Atmospheric science	Tour of the Texas A&M University radar facility, followed by an interpretation of the radar images
Weather on Mars	Atmospheric science	Interpreting the weather on Mars by the Mars Rover
Wetlands Center	Environmental geosciences	Water and biological sampling at the Eddie V. Gray Wetland Center
Seismic	Geology and geophysics	Introduction to seismic waves; interpretation of seismic profiles
Forensic geology	Geology and geophysics	Solving a crime using geological clues and interpretation of geology at the crime scene
Driving on Mars	Geology and geophysics	Plan the route of the Mars Rover and compare to actual path followed by NASA
GPR	Geology and geophysics	Opportunity to use a ground-penetrating radar (GPR) and interpret the subsurface data
Vibracoring	Geology and geophysics	Collect, open, and sample a sediment core from a local floodplain
Stream table	Geology and geophysics	Measurement of erosion and deposition on a stream-table with meandering river
GPS	Geography	Understanding of global positioning systems (GPS) and error through geocaching
Surveying	Geography	Surveying of the beach and nearshore profile at Galveston Island
Rip Currents	Geography	Placement of drogues in an active rip current at Galveston Island
Electricity consumption	Geography	Measure electricity consumption by standard appliances and calculation of demand
Shale gas GIS	Geography	GIS analysis of shale gas extraction in West Texas
Remote sensing	Geography	Measurement of spectral signatures around campus
Ocean cores	Oceanography	Analyze and interpret cores collection housed at the IODP
British Petroleum (BP)	All	Tour of the BP headquarters

laboratory demonstrations led by faculty at various stages in their careers and with a wide variety of background and professional experience. Several of the faculty have developed their GeoX activity into a new classroom activity, whereas others have used GeoX as an opportunity to provide broader effects from their funded projects. Additional activities were developed and administered by BP and the Eddie V. Gray Wetlands Center in the City of Baytown, Texas. A list of the interactive activities that the students participate in during GeoX is provided in Table II. In addition to providing field and laboratory demonstrations, the faculty members and their graduate students discussed opportunities and ways to be successful in University regardless of the participants' decision to attend the College of Geosciences at Texas A&M or elsewhere. Toward the end of the program, university officials from the Admissions Office, Registrars Office, and Scholarships and Financial Aid also explained the mechanics of the college admission process, the availability of financial aid and merit-based scholarships, and the resources available on campus to support student success. The program coordinator, graduate assistant, and undergraduate peer counselors were a constant presence and resource throughout each session to provide continuity for the participants and ensure that they didn't feel as if they were bouncing from presenter to presenter. The participants stayed in the same dormitory with their peer counselors who were also responsible for leading evening social activities and introducing the students to the geosciences program and the university in general.

Parents were engaged directly through an orientation session at the start of the program hosted by the primary author (C.H.) and through summary packets about the different programs in the College of Geosciences. The orientation session was focused on the structure of the camp and the parents did not have an opportunity to meet with faculty, scientists, or university administrators to learn about the geosciences or career opportunities. The parents were also engaged through a reunion barbecue (BBQ) in the fall semester after the program, where they could meet the faculty and administrators involved in the program.

Program Evaluation, Assessment, and Reporting

The effectiveness of the program in recruiting and retaining the selected students in the geosciences was assessed through participant and parent surveys. We did not engage an external evaluation expert; however, the primary author (C.H.) was the faculty lead of the program and acted as the external evaluator as he has on other study abroad and research experiences for undergraduates (REU) programs. The program was administered by the other authors, which allowed C.H. to remain at arm's length in the program evaluation. We used a survey instrument (approved by the relevant human subjects protection program and with parental consent) applied by trained and independent enumerators when the participants and their parents arrived at the program. Development of the program-specific survey was guided by the geoscience pipeline model of Levine et al. (2002) and Fuhrman et al.

TABLE III: Demographic data of the 59 participants in the GeoX program from 2011 to 2013.

Year	White	Hispanic	Black	Other	Male	Female	Rising Junior	Rising Senior	Total
2011	8	6	3	3	7	13	7	13	20
2012	6	7	2	4	6	13	6	13	19
2013	8	8	2	2	8	12	3	17	20
Total	22	21	7	9	21	38	16	43	59

(2004), which proposed that there various personal and institutional factors that determine whether an individual will pursue a career in the geosciences. The preprogram and postprogram participant surveys consisted of demographic data and open-ended questions about their knowledge and perceptions about the geosciences. The English-only survey was also administered to most of attending parents at the start of the program (before the orientation session attended by the parents), with only one parent survey completed per each set of parents attending the preprogram activities. This assumes that the parents had similar views and understanding of the geosciences and represents a limitation of the study.

The preprogram and postprogram surveys asked the participants to respond to a series of statements about science, geoscience, college attendance, and STEM courses taken (or to be taken) in high school. For each statement, possible responses were considered on a 5-point scale using the following values: 1, strongly disagree; 2, disagree; 3, don't know or not applicable; 4, agree; and 5, strongly agree. The use of *don't know* or *not applicable* does not confer a value, and that *neutral* should have been used for respondents who have no strong feelings either way (Krosnick and Fabrigar, 1997; Sturgis et al., 2014). Students were also asked a series of open-ended questions about what topics can be studied in each of the participating programs and career opportunities. Because the field and laboratory activities experienced by the students varied from year to year based on the availability of the participating faculty, the results of the survey are presented in aggregate rather than by program year.

The parent survey also included the open-ended questions used for the students but included additional questions about the number of family, friends, and acquaintances who work or have degrees in various professions (e.g., medicine, law, geosciences, etc.). The parents were also asked to rank those professions based on their perception of the career opportunities and complete a similar ranking for the participating departments in the college (atmospheric science, geography, geology, oceanography, and environmental programs). Parents and students were also asked about the career opportunities for geoscientists in general and for the individual degrees offered at Texas A&M University. At a reunion BBQ the following semester, all of the attending parents were asked the same questions they had previously completed. This final survey was used to assess how the parent's awareness of the geosciences evolved indirectly through their child's participation in the program or directly through their own research during and after the program.

The surveys administered to the students focused solely on whether they learned about the geosciences and the career opportunities in this field, not on whether they intended to pursue a geoscience degree. The effectiveness of the program at recruiting students is based solely on whether the rising seniors applied to a geoscience program that fall. Postprogram mentoring continued through an online learning community, using social-networking sites moderated by the director of recruitment, which connect students with their peers (from within and across different years) and with the faculty mentors. Continued contact with the students allowed the program administrators to determine how many of the participating students pursued an undergraduate program in the geosciences and specifically at Texas A&M University. All admitted GeoX students were required to participate in a 1-y-long 1st-year seminar as well as the Geosciences Peer Mentor program. These two requirements were put in place as a retention initiative to help students settle in the fall, cope with college life, and thrive in their new environment. The GeoX students were mentored by seasoned geosciences students, who guided them for a full academic year to ensure a successful college experience. In addition, GeoX students who were offered an academic or need scholarship by the college or the university were also required to participate in the 1st-y seminar and Peer Mentor Program. Additional surveys will be administered annually throughout their time as undergraduate students to determine how their choice of major and career path evolve.

RESULTS

Demographic and attitudinal data for the 59 participants of the program between 2011 and 2013 are presented in Table III. Consistent with the applicant pool, most of the students were female ($n = 38$; 64%) and rising seniors (73%). Although the recruitment of participants from underrepresented groups was not an important focus of the program, and no extraordinary recruiting effort was made, 28 students (~48%) self-identified as Hispanic or black. As presented in Table IV, all of the students had taken some form of advanced math (100%) and nearly all had taken biology (97%) and chemistry (92%). In contrast, only 14% of the students had taken a course in the earth and space science, environmental science or AP human geography, opting instead for astronomy, aquatic sciences, and other "basic" science electives as available in their respective schools. Despite few of the students having taken a geoscience-related class, their background and preparation in STEM courses suggests that there is a strong likelihood that these students could be recruited into the geosciences (Levine et al., 2002) and that they are well prepared for geoscience courses at the undergraduate level.

Preprogram Survey

At the start of the program, only 46% ($n = 27/59$) considered taking geoscience courses in university, and

TABLE IV: Number of students from each year of the GeoX program to have taken different STEM courses.

Department	2011	2012	2013	Percentage, $N = 59$
Biology	18	19	20	97
Chemistry	16	19	19	92
Physics	12	12	14	64
Math	20	19	20	100
Geosciences	3	0	5	14

fewer still considered majoring in the geosciences (20%, $n = 12/59$). Those students who were considering a career in geosciences included all of the students ($n = 8$) who had taken a geoscience class in high school, whereas the remaining four students (from 2013) knew a friend or family member with a geoscience degree or in a geoscience-related career. Most students (93%, $n = 55$) did not know a friend or family member with a geoscience degree or employed in a geoscience-related career despite the state's economy being deeply rooted in the geosciences including the presence of the U.S. National Aeronautics and Space Administration (NASA) in Houston, Texas, and the development of hydrocarbons in the Eagle Ford shale. This suggests that early preprogram exposure to the geosciences is an important determinant of whether a student will consider the geosciences for an undergraduate degree or as a career option. Despite few of the participants having been exposed to the geosciences in school or through acquaintances, most participants agreed or strongly agreed that the geosciences were fun, important, and useful (Table V). This is not unexpected because the students had to apply to participate in the program, and only those who viewed the geosciences as interesting would have applied.

There is also a clear difference in the free-form responses of both the participants and the parents about what the participants can do with a degree in the geosciences. Those who had no prior exposure to the geosciences in school or through an acquaintance, tended to identify relatively simple responses such as *map maker* (for geography), *oil company* (for geology), *weatherman/woman* (for atmospheric science), *marine biologist* (for oceanography), and *environmental scientist* (for environmental programs). The descriptions of the topics that could be studied in each of those programs tended to be simple:

Atmospheric sciences: *"weather," "meteorology," "the atmosphere," "astronomy," "space," "pollution," "seeing the ozone layer"*
Environmental geosciences: *"the environment," "reduce, reuse, recycle," "environmental issues," "air quality, biology"*
Geography: *"vegetation," "topography," "culture," "cartography," "earth"*
Geology and geophysics: *"rocks," "resources," "volcano's and earthquakes," "dirt"*
Oceanography: *"waves," "tides," "currents," "the ocean," "reefs"*

In comparison, those participants (n = 12) who had prior exposure to the geosciences provided greater detail and nuance in their preprogram responses:

Atmospheric sciences: *"Fluid dynamics, thermodynamics, chemistry, math, forecasting," "how the atmosphere works and which sciences are involved in creating the conditions we have present on our planet," "the layers of the atmosphere, weather patterns, clouds"*
Environmental geosciences: *"Atmosphere pollutants and how to deal with them, groundwater resources"*
Geography: *"Human geography, study of culture, land how it affected people groups, mapping," "the Earth and how human interactions affect it"*
Geology and geophysics: *"Argon-potassium dating specialists for paleoanthropology, rocks, types of rocks."*
Oceanography: *"Waves, trenches, ocean currents, what causes things such as rip currents and tsunamis."*

Irrespective of whether the responses were a complete and accurate description of the geosciences, the average of 11 words per response of the participants with prior exposure to the geosciences was significantly greater than the average response of 2 words by those students with no prior exposure. No statistically significant difference was observed between those students with and without prior exposure to the geosciences with respect to either race ($\chi^2 = 2.3$, $p > 0.05$) or sex ($\chi^2 = 1.8$, $p > 0.05$). The participants from 2013 who had prior exposure to the geosciences through an academic program or through a family acquaintance identified the geosciences as one of the most lucrative (i.e., most financially rewarding and competitive), whereas

TABLE V: Attitudinal data of the 59 participants of GeoX showing percent number of students agreed or disagreed with the statements about science and the geosciences.

Statement	1	2	3	4	5
	Strongly Disagree	Disagree	Don't Know	Agree	Strongly Agree
I am interested in science	0	2	2	38	72
I am good at science	2	0	7	57	34
Science is boring	59	36	5	0	0
I prefer not to study science	67	21	7	7	2
The geosciences are interesting	0	0	5	47	48
The geosciences are fun	0	0	24	40	36
The geosciences are important	0	0	0	21	79
The geosciences are useful	0	0	2	29	69

those who ranked the geosciences as one of the least lucrative had no prior exposure ($\chi^2 = 7.4$, $p < 0.05$).

Postprogram Survey

To assess whether the summer program was successful in increasing knowledge and awareness of the geosciences and career options, the participants were asked the same free-form questions before leaving with their parents. Most participants provided a longer and more-detailed description of the career opportunities in the geosciences and were able to identify specific courses and topics they could study as an undergraduate student. The change in response is based on a comparison of the responses at the start of the GeoX program to the responses at the end of program. On average, the students with prior exposure to the geosciences increased from 11 words per response to 35 words, whereas students without prior exposure provided an average of 33 words compared with 2 words before the program. An independent *t*-test revealed a statistically significant increase in the average word count for both the students with ($t = 28$, $p < 0.05$) and without prior exposure ($t = 38$, $p < 0.05$). No statistically significant difference was observed between these groups following the GeoX program ($t = 0.4$, $p > 0.05$). Representative comments from both groups include:

> *"I came to this camp not knowing anything about Geosciences and what it had to offer. After attending GeoX, I have changed by mind about my dream major and am in the process of deciding to switch from pre-vet to environmental science."*

> *"I learned that Geosciences offer a very wide variety of different fields and with a degree in Geosciences comes a great opportunity of doing things I love to do."*

> *"I learned that there are many job opportunities for geosciences and that there's something out there for every interest. I like a little bit of everything, so I will most likely major in environmental geosciences."*

> *"I've come to realize how underappreciated the geosciences are and how many different things you can do with them"*

> *"I learned so much[;] this program really opened up my eyes to all the possibilities that the geosciences have to offer and how making my career in the Geosciences would change my life, for the better."*

> *"I didn't know the College of Geosciences had so much to offer to me. This week has really opened by eyes to brand new opportunities, waiting outside my doorstep. The only thing left is for me to simply choose what I want and love."*

These free-form responses suggest that the GeoX program significantly improved student awareness of the *opportunities* in the geosciences in addition to an improved description of what they could study in each of the subdisciplines:

> **Atmospheric sciences:** *"Weather patterns over large distances from data collected from a weather balloon or radar. Can predict weather and study clouds."*
>
> **Environmental geosciences**: *"You can study a little bit of all of the above. Biology, chemistry, physics, meteorology, oceanography."*
>
> **Geography:** *"GIS* [geographic information systems], *human dispersion, energy conservation, energy supply, geomorphology." "The Earth's past. You can study rocks, how they were formed and the processes it took to realize their history."*
>
> **Geology and geophysics:** *"The history of Earth sediments from cores: the different layers of sediment over time. Use seismic to discover what is under the ground and oceans."*
>
> **Oceanography:** *"Movement and formation of ocean floor, microscopic plankton that makes the base of food chain, currents and their effect on humans."*

Some of the responses also suggested that the students enjoyed the opportunity for hands-on learning in the field and in the laboratory:

> *"For me, the most interesting demonstrations included looking at the stream table and the core samples at IODP* [International Ocean Drilling Program]. *It was very interesting to learn about some different Earth processes and to be able to do hands-on experiments with this knowledge. I also thought that actually going out and taking core samples ourselves was exciting because it gave me a taste of the field work too, rather than just the knowledge in how to analyze rocks."*

> *"The vibracores were the thing that I was most interested in. I loved all the changes that showed up in the samples. Making inferences about the cores was also very awesome."*

> *"The 3D* [three-dimensional] *simulation and the weather lab were really interesting. I loved launching the weather balloon; it was once in a lifetime. I loved talking about energy conservation with Dr. B, because to me it was very realistic and it's what I think makes the most impact on society."*

> *"I really enjoyed looking at cores with Dr. T. She made everything really interesting and made me think of all kinds of new and different things. I also enjoyed measuring the rip currents with G. I didn't know such a simple/complex job could be so fun. Vibracoring with Dr. H was totally cool."*

All of the students described the hands-on field and laboratory activities positively, particularly those that were both physically and intellectually challenging, such as the vibracoring, rip current measurements, core analysis, tethersonde measurements.

At the end of the program, ~56% of the participants from all years ($n = 33/59$) identified the geosciences as their primary career goal (compared with only 20% before the program), which suggests that the program had a positive effect on participant impressions of the geosciences. In particular, the students identified the geosciences as one of the more-lucrative professions (median rank, 7/8) and equal to the medical profession and more lucrative than careers in engineering and law compared with a median rank of 4/8 before the program began. Based on the Spearman rank correlation coefficient ($r_s = 0.90$), the rankings are positively correlated (and nearly identical) for the parents and the participants before the program suggesting that the parents

had a similar perception of career opportunities in the geosciences before the program. The ranking completed by the parents at the reunion BBQ exhibits a relatively weak positive correlation with their rankings before the program ($r_s = 0.80$) and a strong positive correlation to the student rankings completed after the program ($r_s = 0.93$). Unfortunately, we did not administer the test to the parents immediately after the program due to the nature of the activities on the last day. This would have allowed us to clearly demonstrate that the perception of the parent was associated with postprogram discussions with the participants and is something that needs to be included in future offerings of this and similar programs.

To track whether participants (from 2011 and 2012) did pursue an undergraduate degree in the geosciences, we completed a simple phone and electronic mail–based survey of the participants who applied to an undergraduate program in 2011 and 2012 ($n = 22$). Most students applied to an undergraduate program at Texas A&M University ($n = 17$) and a handful of other geoscience programs at the University of Texas ($n = 2$), the University of Chicago ($n = 1$), the University of Houston ($n = 1$), and Southern Methodist University ($n = 1$). Most students who applied to Texas A&M University identified the geosciences as their preferred major ($n = 14$), whereas the other students identified STEM-related degrees, including engineering and veterinary medicine. All of the students who applied to Texas A&M University were accepted into their chosen major. Of the 2011 and 2012 cohort that applied to Texas A&M University, 8 enrolled in the Department of Geology and Geophysics, 4 enrolled in the Department Environmental Geosciences, and 2 in the Department Atmospheric Sciences. Although we do not yet have data from the rising juniors of 2012 and the entire 2013 cohort, and we have not been able to determine if all of the 2011 and 2012 students will continue in their chosen degree, this initial survey suggests that the program had a significant effect on the recruitment of students into the geosciences.

Open-Ended Parent Surveys

At the start of the program, the parents completing the survey ($n = 48$ for the 59 participants) also had a limited (average, 2-word), and relatively simple views of the geosciences and the career opportunities, including "*meteorologist*" (for atmospheric science), "*conservationist*" (for environmental geosciences), "*teacher*" (for geography), "*petroleum industry*" (for geology and geophysics), and "*marine biologist*" (for oceanography). Many of the parents did not provide an answer when asked to describe the career opportunities in atmospheric sciences, geography, and environmental geosciences. At the fall reunion, the parents ($n = 31/59$ participants) gave longer and positive descriptions of the geosciences with an average word count of 12:

> *"I was unaware of the job opportunities in the geosciences and in particular outside of geology."*
>
> *"I learned about how geoscientists study weather patterns, the history of the earth through cores and currents in the ocean."*
>
> *"I heard about the many rewarding job opportunities in the geosciences…"*
>
> *The close similarity between the postprogram parent and student responses suggests that the parent's awareness of the geosciences increased after the program, either through a transfer from the participant to the parent and/or independent research completed by the parent. When asked about their perception of the academic programs in the College of Geosciences, in general, the parents referred to "tradition of Texas A&M," "small-town feel," "hands-on experience," "small intimate program,"* and *"enthusiasm."*

DISCUSSION

Short-term indicators gathered before and after a 1-wk summer program suggests that the Geosciences Exploration Summer Program (GeoX) effectively increased participant awareness of the geosciences and the range of career opportunities. Before the program, most of the participants had little to no exposure to the geosciences in high school or through a relative or close acquaintance. As a consequence, the participants and their parents had relatively simple views of the geosciences, except for those with prior exposure to the geosciences through acquaintances and academic programs. Results suggest that those with prior exposure tended to view the geosciences as a rewarding career, compared with those who had no previous exposure to the field who believed that geoscience was not a lucrative field. Following the program, the participants had a more-positive attitude toward the geosciences and were able to provide greater detail and description of the subdisciplines and their respective career opportunities. For example, the students perceived the geosciences to be lucrative (i.e., financially rewarding) immediately after the program, whereas their parents did not perceive the geosciences to be lucrative at the start of the program. Student responses about the program suggest that it was the challenging hands-on activities that provided them with the greatest understanding of the geosciences (see also Haller et al., 2010). At the reunion BBQ, the parents had an improved perception of the geosciences as lucrative, suggesting an improved understanding of the geosciences after the program.

Although the decision of the student to apply to the GeoX program suggests that they had some prior interest in the geosciences, the presurvey and postsurvey suggest that the students' perceptions were altered by the program and that recruitment of students into the geosciences depends on increased exposure in high school and even earlier. Despite the participating students of GeoX being required to take a geoscience course as one of their capstone electives, most students did not take a course in earth and space science, and fewer still knew a friend or family member with a geoscience degree or employed in a geoscience-related career. The lack of exposure during high school, combined with the relatively low chance of students and parents knowing or interacting with anyone in the geosciences, limits the number of students who consider a degree in the geosciences. Results of the present study suggest that exposure and awareness are key to early decisions about whether to pursue a career in the geosciences and that short science programs can have a positive effect on student perceptions (Schacter and Jo, 2005; Doerschuk et al., 2007; Fields, 2009; Foster and Shiel-Rolle, 2011). Despite the state's economy being deeply rooted in the geosciences, courses in the geosciences (including earth and space

sciences, environmental sciences, and human geography) are no longer required for graduation and tend to be taken by the few students completing the distinguished graduation track. This problem is compounded by the relatively few teachers with a geoscience degree or exposure to the geosciences during their undergraduate degree. Only if the teachers are exposed to the geosciences can they confidently expose their students to the geosciences directly or indirectly in traditional STEM classes (McNeal, 2010; Levine et al., 2009).

Levine et al. (2007) suggest that recruitment programs also need to engage adults and parents to ensure that the entire family recognizes the geosciences as a potential academic and career path. Parents were directly engaged during an orientation session at the start of the GeoX program, through the distribution of materials about the different majors and programs in the College of Geosciences, and through a reunion BBQ in the fall semester following the GeoX program. The perspective of the parents and their awareness of the geosciences appear to be indirectly altered by the students who were positively affected by the program. This suggests that parents do not necessarily need intensive engagement as suggested by Levine et al. (2007), just some level of direct and indirect engagement. Because an immediate postprogram survey was not administered to the parents it is not possible to determine whether the materials provided to them at the start of the program altered their perspective of the geosciences, but it is reasonable to assume that the materials had little direct effect on the parents compared with the transfer of enthusiasm and information from the students to the parents. Further study is required to determine the relative effectiveness of direct intervention through presentations and program materials in changing parent perceptions and understanding of the geosciences compared with indirect intervention through student enthusiasm and interest following the program.

Regardless of how their perspectives were changed, the parents may not have encouraged their children to pursue a geoscience career without the GeoX program, opting instead for known fields (e.g., medicine, law and engineering). Only those participants with exposure to the geosciences before the program identified the geosciences as a career option and ranked geosciences careers as more rewarding. Few high-school students in the state of Texas take geoscience-related courses at those schools fortunate enough to offer them as science electives, despite the importance of the geosciences to the economy of Texas. Simply exposing students to the geosciences has proven to be an effective pipeline for students to pursue the geosciences (Miller et al., 2007), and the results of this study suggest that exposing the parents is also important. At the reunion held several months after the program, the parents clearly had an improved awareness and attitude toward the geosciences and most of the participants from 2011 and the seniors from 2012 are now enrolled in a geoscience program at either Texas A&M University or another program. In this respect, it seems that the GeoX program was (in part) successful because it increased parent awareness of the geosciences and attitude in the geosciences indirectly through student enthusiasm and interest (see Levine et al., 2007). Consistent with Seymour (2002), positive experiences and learning about science careers through GeoX translated into more students pursuing a degree in the geosciences. At the time that this manuscript is being prepared, 55% of the participants (from the 2011 and 2012 cohorts) are now pursuing an undergraduate degree in the geosciences, compared with only 20% of participants who were planning to pursue a geosciences degree before the program, because they were introduced to the geosciences in a manner that bridged the gap caused by income, geographic location, or prior exposure to the geosciences (e.g., Miller et al., 2007; Baber et al., 2010).

Although the program appears to be successful in recruiting students to the geosciences, long-term tracking of participants is still required to determine whether the participants are retained in college (see GeoFORCE, 2013). Retention may require longer-term contact and mentoring to ensure that the interest levels of the students are maintained. The more opportunities and the longer a student is able to persist within a degree, the greater the long-term attitudes and knowledge retention (Dettmann-Easler and Pease, 1999). As discussed by Baber et al. (2010), a lack of preparation in math and science by underrepresented students can make it difficult for the students to be admitted to a geoscience program. However, this also depends on direct and indirect support of the parents in the choice of degree paths and the confidence of both the parents and the students in career opportunities. In this respect, future offerings of this and similar programs should put greater emphasis on engaging the parents to ensure that the geosciences are recognized as a potential academic and career path and are supported by the family.

It is important to recognize that the results of the present study are not conclusive and that the influence of the parents on a students' decision to study geoscience is unclear and merits further investigation. Future offerings of the GeoX program will directly involve the parents through faculty-led activities and lectures to increase their understanding of the geosciences, which will require additional surveys of the parents before and after this new intervention. To determine how their perceptions of the geosciences changed through direct and indirect interventions, we will also ask the parents to reflect on how and why their understanding changed. A further change is to consider the impact of this recruitment program on the faculty who generously donate their time to developing and leading the field and laboratory activities. As noted, several of the faculty have developed their GeoX activity into new classroom activities, whereas others have used GeoX as an opportunity to provide broader impacts from their funded projects and proposals. In this respect, future iterations of the program will not only focus on introducing students to the geosciences but also on increasing awareness of the geosciences with the parents and identifying ways to invest more faculty into this and similar recruitment programs.

CONCLUSIONS

A 1-wk recruitment program in the College of Geosciences at Texas A&M University introduced rising junior and senior high-school students to opportunities and careers in the geosciences. Results from preprogram and postprogram surveys of participants and their parents suggest that there is an increase in participant awareness of the geosciences and interest in pursuing a degree in the geosciences. The

participants and their parents had relatively limited knowledge of the geosciences at the start of the program, and very few had friends or acquaintances employed in the geosciences, despite the importance of the geosciences to the state economy. The participants had improved and nuanced understandings of the geosciences and career opportunities, and the newfound enthusiasm and interest of the student helped educate the parents about the geosciences. Although few students were planning to pursue a degree in the geosciences at the start of the GeoX program, 55% of the participants from the 2011 and 2012 cohorts are now pursuing undergraduate degrees in the geosciences. Although the influence of the parents on a students' decision to study geoscience is unclear and merits further investigation, results suggest that the parents do not necessarily need intensive engagement, just some level of direct and indirect engagement through the program and by the students.

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