Pathways to the Geosciences Summer High School Program: A Ten-Year Evaluation

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ABSTRACT

The high demand for scientists and engineers in the workforce means that there is a continuing need for more strategies to increase student completion in science, technology, engineering, and mathematics (STEM) majors. The challenge lies in finding and enacting effective strategies to increase students' completion of STEM degrees and in recruiting students to these disciplines, especially those from underrepresented minority groups. This article presents results from 10 years of data from collected during a 2-week summer program for high school students in geosciences targeted at participants of Hispanic American origin in El Paso, Texas. The short-term goal of the program was to introduce the students to the geosciences and to inform them of the possibilities of the geosciences as a college major and career choice. The long-term goal was to form a pipeline from the summer program to undergraduate and graduate programs at the University of Texas at El Paso. Short-term indicators show statistically significant positive changes in student attitudes towards science and the geosciences over the course of the program. Long-term indicators show that 55% of the participants entered STEM majors in college and that 20% either are or were geoscience majors in college. By comparison, nationally only 9% of geoscience bachelor's degree graduates are from underrepresented minorities. These results suggests that summer high school programs in the geosciences can have a significant impact on increasing the number of underrepresented minority students who choose the geosciences for a career.

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Key words: geoscience recruitment, summer programs, quantitative study, pipeline

INTRODUCTION

The high demand for scientists and engineers in the workforce means that there is a continuing need for more strategies to increase student completion in science, technology, engineering, and mathematics (STEM) majors, allowing them to enter the workforce to enjoy successful careers in these STEM disciplines. The challenge lies not only in finding and enacting effective strategies to increase students' completion of STEM degrees, but also in recruiting students to these disciplines, especially those from underrepresented minority groups. Here we use the National Science Foundation's (NSF) definition of underrepresented groups, which includes African Americans, Hispanic Americans, Native Americans, Native Pacific Islanders, Native Alaskans, and persons with disabilities.

Among the STEM disciplines, the geosciences are a relatively small field in terms of numbers of students and professionals. For example, in 2010, fewer than 1% of bachelor's degrees awarded in STEM came from the Earth, Atmospheric, and Ocean Sciences (National Science Foundation [NSF], 2013a). Yet, knowledge in basic geoscience fields is essential to enhancing many areas of modern society, including the discovery and development of energy resources and sustaining the global environment.

When it comes to the population of undergraduate students from underrepresented minorities in geosciences, the shortage is acute. In 2008, underrepresented minorities comprised 23% of all enrolled students and 16% of all graduates from 4-year universities, while fewer than 10% of geoscience graduates at all degree levels were underrepresented minorities (Gonzalez and Keane, 2011). At 8%, the geosciences conferred the lowest percentage of bachelor's degrees to students from underrepresented minorities compared to all other science and engineering fields, which averaged approximately 12% in 2010 (NSF, 2013b).

A decision to pursue a STEM major is a longitudinal process that begins during secondary education and carries into postsecondary studies (Wang, 2013). Here again, the geosciences as a discipline face a distinctive challenge, as course work in the field is rarely required after middle school. Geology and environmental science classes are sometimes offered at the high school level, but typically only as electives. For example, in the El Paso, Texas, area where the data presented in this study were gathered, only three or four of over 40 high schools have ever offered a geosciences course within the last 10 years. Further, even though El Paso is in Texas, it lies far from the petroleum producing regions of the state and few professionals in the community pursue careers in the geosciences. Without other means of exposure, high school students are not likely to be aware of the geosciences as a career choice.

An alternative is to introduce students to the geosciences through a summer program. Indeed, summer programs are a common strategy for increasing interest in and recruitment to STEM careers in general among K–12

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students (e.g., Atwater et al., 1999; Knox et al., 2003; Bischoff et al., 2008). Here we report on 10 years of data collected from a 2-week summer program, held at the University of Texas at El Paso (UTEP) that was designed to introduce high school students from groups underrepresented in STEM to the geosciences. The long-term goal of the program was to form a sustained pipeline of students from El Paso high schools to undergraduate majors in geological sciences and eventually to graduate programs and careers in the geosciences. We note that El Paso, with a regional population of greater than 800,000 of which more than 80% is Hispanic, is fertile ground for recruiting such students into STEM disciplines.

In order to assess the effectiveness of the program in meeting its goal, we designed and administered surveys to participants on an annual basis. A total of 245 students participated in the program over 10 years. Short-term indicators from the survey data show statistically significant positive changes in student attitudes towards science and the geosciences as a result of participation in the program. The long-term indicators show that 55% of the participants remain in the geoscience pipeline as defined by Levine et al. (2007), and that 20% either majored in or are currently enrolled in a geosciences major.

BACKGROUND

Education and training programs in the STEM fields have long been regarded as an essential element of growing the workforce and assuring national competiveness in science and technology (e.g., National Research Council [NRC], 2007). Numerous federal agencies provide support for such programs (e.g., National Science and Technology Council [NSTC], 2011; NRC, 2013) as have a number of private and corporate foundations. Despite all these investments, it remains difficult to identify successful programs with confidence. For the Earth sciences, this predicament was highlighted in a recent NRC report (NRC, 2013). Among the committee's charges in producing that report were (1) the identification of criteria for evaluating the success of Earth science education and training programs in federal agencies, and (2) using these criteria and the results of previous federal program evaluations to identify examples of successful programs in federal agencies. A central finding of the report is that "very few programs in the Earth sciences have been formally evaluated or structured in a way that facilitates evaluation" (p. 29), making it difficult to complete the charges.

Summer programs are regarded as a proven approach for stimulating the interest of underrepresented minority students in STEM fields (NRC, 2011). Even so, the literature on such programs specific to the geosciences is still sparse and with one exception lacks the kind of data on short- and long-term indicators that we present here. For example, Serpa et al. (2007) document a summer program that persisted for 10 years but did not use quantitative evaluation methods. Adetunji et al. (2012), Murray et al. (2012), and Houser et al. (2015) all present short-term indicators of success from pre- and postsurvey data, but document at most a few summers-worth of results. It is worth noting that GeoX, the program documented by Houser et al. (2015), is patterned after the program documented here, a result of a coauthor's move. Only GeoFORCE (2014) presents long-term data on college outcomes for participants, although these results have yet to enter the peer-reviewed literature. The data and analysis presented in this article are a first step toward filling the data gap in the literature for long-term measures of successful summer programs for underrepresented minority students in the geosciences.

PROGRAM DESCRIPTION

Beginning in June 2002 and lasting for 10 years, the faculty of the Department of Geological Sciences at UTEP led a summer outreach program called Pathways to the Geosciences (henceforth, Pathways), which was designed to enhance awareness of the geosciences among local high school students. The program was designed to give participants an introduction to (1) a broad spectrum of the geosciences ranging from environmental geology and satellite image analysis to structural geology and geophysics, (2) career opportunities in the geosciences, and (3) the college application process including financial considerations. Each 2-week session was limited to 15 high school participants. In addition to the recruitment of the students, three high school teachers were recruited to attend the program(s) in order to facilitate bringing more geosciences content into the high school science classrooms. Aspects of the work with teachers are outlined in the supplemental materials.

The program was held each summer for a 2-week period, Monday through Friday, from 8:00 a.m. to 3:30 p.m. Some years the program was offered in two 2-week sessions, while in other years, due to limitations on funding and/or faculty and staff availability, the program was only offered as a single 2-week session. During each session, participants engaged in a variety of field and laboratory projects located in and around UTEP and the broader El Paso region (Table I).

RECRUITMENT AND SELECTION OF STUDENTS

Originally, the Pathways summer program targeted students who already had a strong interest in science or engineering and were entering either their junior or senior year of high school following the summer program. The junior year was originally targeted for two reasons. First, this is an age when most high students are seriously considering college and career choices. Thus, the original hypothesis was that the program would have a measurable influence on those choices. Second, there was an interest in demonstrating the feasibility of establishing a pipeline between the high schools and the geological and environmental sciences majors at UTEP and other universities within a relatively short period of time (Miller et al., 2007).

In 2005, the junior/senior level criterion was changed as a result of reviews of 3 years of pre- and postsurveys, which showed that by the time that students were high school juniors, most were already very set in their career and college choices. Although they enjoyed the program, there was little indication that the participants would consider changing their college major to the geosciences, at least in the short term. This was a surprise since anecdotally we know that it is not unusual for students to change their major once they are actually enrolled. For example, among the UTEP Depart-

TABLE I: List of typical program activities and projects.

	Activities and Projects
Day 1: *El Paso geology* (on and off campus)	Observation skills
	Analog modeling
	Hike along Transmountain Road in El Paso
	Analog building of the Franklin Mountains
Day 2: *Search for the pipe* (off campus)	Measuring conductivity
	Measuring resistivity
	Measuring gravity
	Using GPR
Day 3: *Mount Cristo Rey, fossils* (off campus)	Day trip Mount Cristo Rey, NM
	Dinosaur footprints
	Structures, faults, folds, and laccolith contact
	Fossil collecting
Day 4: *Local water treatment* (off campus)	Visit to local waste water treatment plant
	Visit to local desalinization plant
Day 5: *Geophysics* (on campus)	Introduction to geophysics, seismic waves, and earthquakes
	Convection cells and viscosity
	Looking at the ocean floor
	"Journey to the Center of the Earth"
Day 6: *Seismic refraction* (on and off campus)	Field trip for seismic refraction experiment to look for the water table
	Laying the geophones for the experiment
	Collecting data from the geophones
	Data analysis
Day 7: *Volcanoes* (on campus)	Volcanoes discussion
	Mentos eruption experiment
	Viscosity, lava
	Monitoring a volcano experiment
Day 8: *Plate tectonics* (on campus)	Earth's structure
	Mapping earthquakes
	Plate tectonic maps
	Edible plates with Oreos
	Tsunamis
Day 9: *CSI: UTEP* (on campus)	Geology circus
	Density
	Forensics and structure
	Topographic profiles
Day 10: *Wrap up day* (on campus)	Careers for Geoscientists, video and discussion
	UTEP college recruitment, financial aid
	Swimming pool fun

ment's own undergraduate majors, most had changed their initial major before finally choosing the geosciences. In fact, it was not uncommon that these students actually change majors multiple times.

Based on these results, we modified our participant selection preference to students who had completed their freshman year of high school, beginning in the summer of 2005. Our reasoning was two-fold: first, a number of local high school teachers indicated to us that students in this age group were still very open-minded toward different career paths and college majors compared to junior and seniors. Second, completion of the freshman year meant that the participants would have sufficient basic math and science background to benefit from the program.

Students were recruited through various means including: (1) contacting science facilitators (district level staff charged with overseeing science curriculum and professional development of teachers) in the El Paso area school districts; (2) contacting the science directors at many of the local high schools directly; (3) via the Pathways program Web page (which is no longer maintained); and (4) advertising within Education Service Center–Region 19 (www.ecs19.net), the educational service center for 12 local public school districts. Region 19's main goal is to aid teachers and administrators in their role as educators of children. This organization acts as a link between the districts and charter schools within the region and the Texas Education Agency (TEA) in Austin.

A significant effort was made to recruit excellent science students. In midspring of each year, the Pathways Program Coordinator (T.L.C.) met with each of the district science facilitators and provided them with posters and brochures advertising the program, as well as applications for enrollment. If time was available at these meetings, a short presentation about the summer program was also given. The science facilitators in turn distributed the materials to representatives from each of the high schools during their regular monthly meeting with science department directors, chairs, or heads. Mailings were also sent directly to science department heads with material describing the program and providing them with the applications, posters, and brochures. Another recruitment tool was a Web page, where students were able to read about the program and download the application form. Typically, most of the area high schools had received the posters and brochures, and the applications for the students by mid-April.

Students were selected for the program based on several criteria including grade level, an overall grade point average, teacher recommendation, and a narrative written by the student on why she or he was interested in attending the program and what they hoped to gain from the experience. The written narrative and overall grade point average were given the most weight in selection criteria, although the latter did not give us any information on actual grades obtained in math and science courses. If questions about an applicant arose, we would contact the teacher that recommended the student. Participant selection was completed by mid-May of each year.

Typically, two 2-week sessions were held each summer. Each session included 15 students, for a total of 30 participants each summer. Over the course of 10 years we received over 900 applications and 245 students ultimately participated in the program.

Each participant selected received a small stipend in exchange for completion of the program. This amount was designed to be competitive with a part-time job and an incentive to complete the program, as checks were issued on the last day of the session. Originally, when recruiting juniors and seniors, the stipend amount was $300. When the age level was lowered, the stipend amount was reduced to $200.

PROGRAM ACTIVITIES

The El Paso region provides a natural setting for exploring geoscience topics and environmental issues. The region is located at the southern end of the Rio Grande Rift, the City of El Paso surrounds the Franklin Mountains, and it lies within the great Chihuahuan Desert. Because of these major features, geology is very prominent locally with features such as fault scarps, rift basin and range topography, volcanoes and volcanic features, and desert landscapes that are highly visible and accessible. In addition, because of its location on the border with Mexico, the El Paso area shares many environmental challenges with its border city, Ciudad Juarez. In turn, many of the activities in the Pathways program were chosen to highlight the local geologic and environmental setting and take advantage of the participants' natural curiosity about their surroundings (Table I).

Since geology was not taught in most of the local high schools, we sought to introduce the students and teachers to a broad range of geoscience concepts and to demonstrate how many of these concepts were applications of more familiar content in biology, chemistry, and physics. In fact, an important consideration in preparing the activities was to develop content that met the science education standards in the Texas Essential Knowledge and Skills (TEKS; Texas Education Agency, 2010). Throughout the program, we found that the geoscience concepts were often as new to the teachers as they were to the student participants. In this sense, the teachers participated in a similar capacity to the student by learning and experiencing new geoscience concepts through hands-on activities.

Field-based and hands-on activities and projects that promoted critical thinking and inquiry-based learning were incorporated into the program, reinforcing the basic concepts of the scientific method. A typical activity (Table I) would encompass a simple experiment or demonstration that took less than a few hours to complete. Some examples that participants really enjoyed included simulating plate boundaries with Oreo cookies, a "Mentos in Diet Coke" demonstration as an example of a gas-driven eruption, and an off campus trip to the local water treatment or desalinization plant. Projects were more elaborate. A typical project might include a full day of fieldwork mapping and collecting samples, and perhaps a second day for processing samples, data reduction, and discussion. This type of exercise allowed participants to carry out a project from beginning to end to reflect on what was accomplished and on how the process could be improved in the future (Miller et al., 2007).

The Pathways program was also designed to provide the student participants with exposure to a variety of role models in the geosciences. In a typical session, students would take part in approximately 10 different activities. A different faculty member usually led each of the activities with the assistance of several graduate and undergraduate students. The participants were thus able to meet a larger number of geoscientists of diverse backgrounds, in various stages of their careers. For example, Hispanic, Native American, differently abled, and female faculty members all led activities during the program. Graduate students included Hispanic American, Asian American, and female participants.

On the last day of each session, participants attended a half-day activity comprised of an introduction to college entrance requirements, financial aid, scholarships, and academic opportunities at UTEP. Information on the relative cost of attendance at a 4-year university compared to a community college was discussed. Other benefits of community colleges, such as smaller class size, greater availability of required freshman and sophomore level courses, and greater faculty/student interaction, were also included in this activity.

PROGRAM EVALUATION

For this study, we were mainly concerned with evaluating the impact that the Pathways program had on students in terms of their entry and retention in the geosciences pipeline. Our approach to evaluating the impact on students builds upon the geoscience pipeline model for underrepresented groups described by Levine et al. (2002, 2007) and Fuhrman et al. (2004). These authors suggest that several factors contribute to the increased likelihood that an individual will choose a geoscience career path, including parental support, exposure to geoscience classes, experiences in the outdoors, experiencing extraordinary geosciences events, taking introductory geosciences courses, accessibility of geoscience faculty, and participation in informal interactions and social activities in a geoscience department. Levine (2007) also states that taking STEM classes in high school is an important predictor. Without a strong background in rigorous STEM classes while in high school, minority students are less likely to remain in the STEM pipeline, let alone the geoscience pipeline model. Another pipeline indicator is preparation for college, specifically, taking the SAT or ACT (tests usually required for college admittance). Finally, we note that Levine et al. (2007) regard individuals who choose a STEM major other than in the geosciences in college as remaining in the pipeline, since for them, a professional track begins with graduate school. We adhere to this view in this article.

Keeping these factors in mind, we developed three types of survey instruments: pre- and postparticipation surveys, formative evaluation of daily activities, and annual postparticipation surveys. These surveys were aimed at collecting data about the short- and long-term indicators that participants would enter and be retained in the geoscience pipeline. Working with American Institutes for Research, the independent evaluation group engaged by the NSF Opportunities for Enhancing Diversity in the Geosciences (OEDG) program that funded this work, we designed pre- and postparticipation surveys to collect data on student demographics, knowledge and attitudes towards the sciences and geosciences, and students' educational plans. Surveys for formative evaluation of daily activities were designed to aid in improvement of program activities. Another survey was administered annually after participation to assess the permanency of changes associated with participation, as well as to determine students' major and career plans (Miller et al., 2007).

All survey instruments were approved prior to dissemination by UTEP's Institutional Review Board (IRB). Prior to IRB submission, members of the design team reviewed the surveys for face validity. Among these were a number of authors on this article, two team members from American Institutes for Research, and some other geosciences professors. Although none of the intended participants reviewed the survey, no participants indicated that they did not understand items, nor did our results suggest they did not understand them.

Additional IRB approvals were required because the majority of the participants were minors. Participants and parents were required to sign and return contracts that included explanations of and expectations for the program. In order to maintain confidentiality and linkage between the pre-and postsurveys, the participants used a personal school identification number as an identifier on surveys. Completed surveys and all data associated with this study were stored in a locked cabinet in the first author's office.

Pre- and Postparticipation Surveys

The preparticipation survey was administered on the first day of a session. In order to not to influence responses to any of the survey questions, each student completed the preparticipation survey after a very brief welcome to the program. Postparticipant surveys were completed on the last day of the session. The pre- and postparticipation surveys developed for the program used a 5-point Likert scale and asked participants to respond to a series of statements on science, geoscience, college attendance, major, and future plans to enroll in STEM courses.

Survey results were analyzed with SPSS Statistics software (IBM, Armonk, NY; http://www-01.ibm.com/software/analytics/spss/products/statistics/). For analysis purposes, responses were treated as interval data. For example, in some questions, participants were asked to indicate the extent to which they agreed with statements such as "the geosciences are interesting." For analyses, responses were assigned the following values: strongly disagree = 1; disagree = 2; don't know = 3; agree = 4; strongly agree = 5.

For each statement or question, mean responses and standard deviations were calculated. In addition, when identical items were asked in the pre- and postparticipation surveys, both parametric (paired sample *t*-test) and non-parametric tests (Wilcoxon signed ranks tests) were performed to determine if there was any statistically significant change in the means of the participants' pre- and postresponses. If there was a statistically significant change in the means, an effect size calculation (Cohen's *d*) was also performed.

The reliability of the 13 Likert items regarding attitudes about science in general and the geosciences in particular (Table VI), was determined using Cronbach's alpha. The negatively worded items were recoded and the reliability was calculated on both the pre-and postsurvey data. The presurvey reliability was 0.689, and the postsurvey reliability was 0.750 (Nunnally & Bernstein, 1994, pp. 264–265). Whereas the presurvey reliability could be considered to be on the low side, the postsurvey reliability is perfectly acceptable. Further, it is important to note that we are not calculating or analyzing a scale score, but reporting significant changes on items of interest to us.

Formative Evaluation Surveys

At the end of each activity on most days, participants filled out a survey designed primarily to provide insight into effectiveness. For example, these surveys asked for brief feedback on what was learned, strengths, weaknesses, and possible improvements. When the survey results pointed to obvious ways to improve the activity, it was subsequently modified.

Annual Postparticipation Survey

To determine whether a participant stayed in the geoscience pipeline, an annual survey was sent each summer to previous participants. Two different surveys were mailed: (1) a survey for students that were college age eligible, and (2) a survey for current high school students.

The survey for college aged participants posed questions toward college and college attendance such as:

- What college have you attended or will you attend?
- What do you plan to major in?
- How likely is it that you would take a geoscience course before you receive your college degree?
- Five or ten years from now, how likely is it that you'll be working in the geosciences field?

The survey for current high school students had questions such as:

- Which of the following math or science courses have you already taken?
- Were the geosciences incorporated into the math and science courses that you took this past year?
- Did the Pathways summer camp help you in the math and science courses that you took this past year?
- What colleges are you considering going to?
- Are you considering the geosciences as a major?

RESULTS

The Pathways program ultimately introduced 245 high school students to the geosciences between 2002 and 2012. In the fall of 2003, the pre- and postparticipation surveys were redesigned to elicit more precise responses from attendees. Because of this, the short-term indicators from the 2002 program data were not used in this study. Therefore, the statistical analysis sample number (n) for short-term indicators was 230. Long-term indicators, specifically the college tracking data, from the 2002 cohort, however, are included in this study ($n = 245$).

Demographics

Demographic data (Table II) were collected during the summers from 2003–2012. During this time frame, there were 16 summer program sessions that took place with a total of 230 participants. Of those 230 participants, a little over half were female (52%). More than three-quarters (78%) were Hispanic.

TABLE II: Participant demographics.

2003–2012 Cohorts	Number of Participants ($n = 230$)	% Participants
Gender		
Male	111	48%
Female	119	52%
Grade Level		
Entering 10th grade in the fall	99	43%
Entering 11th grade in the fall	94	41%
Entering 12th grade in the fall	37	16%
Race/Ethnicity		
African American	4	1.7%
Asian	8	3.5%
Hispanic	179	78%
Native American	1	0.4%
Pacific Islander	2	0.8%
White	33	14.3%
Other	3	1.3%

TABLE III: Participant academic background.

2003–2012 Cohorts	Number of Participants ($n = 230$)	% Participants
High school mathematics courses taken		
Algebra I	228	99%
Algebra II	104	45%
Geometry	164	71%
Precalculus	27	12%
Calculus	2	1%
High school science courses taken		
Biology	167	73%
Chemistry	77	34%
Physics	34	15%
Geology	12	5%

Academic Background

Participants were well prepared in mathematics and the sciences. In mathematics, 99% had taken algebra 1, 71% had taken geometry, and several had taken precalculus (Table III). In the sciences, 73% had taken biology, and 34% had taken chemistry. A small percentage (5%) of the participants had already taken a geoscience course. This particular result was not surprising since the majority of the area high schools do not offer a geosciences course. According to Levine et al. (2002), having an academic background characterized by a high level of preparation in math and science is diagnostic of students in the geoscience pipeline and suggests that this group has a higher likelihood of being retained in the pipeline.

Long-Term College Plans

To assess whether the summer program had any positive effect on the participants' long-term plans for college, survey items were designed to address the likelihood that the participants would attend college (Table IV) and the likelihood that they would take a range of STEM courses while in college (Table V). The presurveys showed that 99.57% of the participants planned on attending college, whereas the postsurveys showed that 100% planned on attending college.

One item, focused on likelihood of attending college, was aimed at attendance at UTEP. In response to the item, "I will attend the University of Texas at El Paso" (Table V) there was a statistically significant change with a mean response of 2.57 and 2.75 on the pre- and postsurvey, respectively. This positive change may be a result of several factors. First, participation in the summer program introduced the participants to professors, graduate students, and the university campus. Many participants had never visited the UTEP campus nor had they been exposed to a college classroom with a university professor. Second, the formative surveys indicated that the participants found the half-day session on college entrance requirements, financial aid, scholarships, and academic opportunities at UTEP to be very helpful. By learning what was required for college enrollment (e.g., SAT, ACT, GPA), the application process (e.g., when to begin, where to go), and information on financial aid (e.g., what is available, FAFSA form), they may have felt more prepared to embark on the process.

Another item focused on community college options. The response to the item "I will attend a community college" had a statistically significant change with a mean of 1.95 to 2.04 on the pre- and postsurvey, respectively. Again, we interpret this positive change to stem from a presentation on the benefits of the community college that introduced the participants to the idea that community college was a viable starting point for a college career.

With respect to the likelihood of studying STEM fields in college the data indicate statistically significant positive changes between pre- and postsurveys (Table V). Initially, this result was a surprise to us. As the participants were already relatively well prepared in high school math and the science, we inferred that they already knew that they would take college courses in specific STEM fields and expected little change over the course of the program. Reasons for the positive change include the possibility that the program increased participants' enthusiasm for majoring in STEM fields, or that it increased their confidence in their ability to complete a STEM major in college.

One last item included only in the postsurvey was "After participating in Pathways would you like to become a geoscientist?" To this, 24% responded "yes," 68% responded "maybe," and only 8% responded "no." Thus, 92% of the participants indicated either that they would like to become a geoscientist or were at least considering the option at the close of the program.

TABLE IV: Likelihood of attending college.

Statements	Preparticipation Average Response Mean[1]	Postparticipation Average Response Mean	Effect Size
2003–2012 cohorts			
I will attend UTEP.	2.57	2.75[3]	0.25
I will attend a university other than UTEP.	3.08	3.05	
I will attend a community college.	1.95	2.04[2]	0.10

[1]1 = I will definitely not attend; 2 = I will probably not attend; 3 = I will probably attend; 4 = I will definitely attend.
[2]Indicates statistically significant $p < 0.05$.
[3]Indicates $p < 0.001$. Effect size: 0.2 = small; 0.5 = medium; 0.8 = large.

Attitudinal Changes

Data on changes in attitude toward science and geoscience were also collected from the surveys to develop short-term indicators of whether participation in the Pathways program increased the likelihood of retaining the participants in the geoscience pipeline (Table VI). These data show significant positive changes in attitudes towards the geosciences for six of seven items. We attribute the large positive change in response to the item "the geosciences are well paid" to a brochure (designed by the Texas Higher Education Coordinating Board (THECB) and Texas Education Agency (TEA)) we provided to participants that showed geoscientists as having the fourth highest paying job (among those listed) in Texas (THECB and TEA, 2002). When choosing a college major, potential earnings in that field are a significant factor (Montmarquette et al., 2002).

Changes in attitudes towards the sciences were also positive. For example, there was a statistically significant change when responding to "I am interested in science" with a mean of 4.38 and 4.52 on the pre- and postsurvey, respectively, and for "I am good at science" with a mean of 4.01 and 4.11 pre- and postsurvey, respectively.

In response to the statement "Science is boring," the mean response was 1.60 and 1.53 pre- and postsurvey, respectively. We saw a decrease in the mean moving the average response closer to a scale of 1, "strongly disagree." For the statement "If I had a choice, I would not study science at school," again, there is a decrease in the average response moving closer to a scale of 1, "strongly disagree" with a mean of 1.70 and 1.59, pre- and postsurvey, respectively.

Based on these short-term indicators, the Pathways program clearly made a positive impact on the participant's attitudes towards both the geosciences and science.

Retention in the Geoscience Pipeline

To determine whether participants stayed in the geoscience pipeline, an annual survey was sent to all of the participants. Two different surveys were mailed: (1) a survey for students that were college-age, and (2) a survey for current high school students.

Including the initial pilot program in 2002 through 2012, 206 of the 245 participants have graduated from high school and are college eligible. Of these 206 participants, 86 responded to the college-age survey at least once. This was an overall return rate of 42% on the surveys. Of these, all were in college at the time of their most recent response. Of these 45% (39) were enrolled at UTEP and 19% (16) were enrolled at the El Paso Community College (EPCC; Table VII).

Of the 86 participants, 55% (47) were in the geoscience pipeline, as measured by a choice of STEM discipline as a college major, and 20% had become geoscience majors (Table VIII). In addition, 75% (65) of the respondents said they will either probably or definitely take a geology course in college. Among that 20% majoring in geology, one participant completed an MS degree in Geology and two are currently enrolled in master's programs in Geology. Furthermore, for the academic year 2012–2013, nine Pathways program alumni were enrolled in the geosciences curriculum at UTEP. Of those nine students, one is currently a master's student and will be continuing graduate education in a PhD program at a

TABLE V: Likelihood of studying STEM fields in college.

Field	Number of Participants	Preparticipation Average Response Mean[1]	Postparticipation Average Response Mean	Effect Size
2003–2012 cohorts				
Physics	229	2.82	3.12[3]	0.40
Chemistry	229	2.89	3.10[3]	0.25
Computer science	227	2.72	2.85[2]	0.15
Mathematics	228	3.23	3.47[3]	0.29
Engineering	229	2.95	2.93	
Biology	228	2.94	3.04	
Geosciences	229	2.89	3.10[3]	0.33

[1]1 = I will definitely not study, 2 = I will probably not study, 3 = I will probably study, 4 = I will definitely study.
[2]Indicates statistically significant $p < 0.05$.
[3]Indicates $p < 0.001$. Effect size: 0.2 = small; 0.5 = medium; 0.8 = large.

TABLE VI: Participant attitudes toward science and geoscience.

Statements	Preparticipation Average Response Mean[1]	Postparticipation Average Response Mean	Effect Size
2003–2012 cohorts			
I am interested in science.	4.38	4.52[3]	0.24
I am good at science.	4.01	4.11[2]	0.13
Science is boring.	1.60	1.53	
Science is a hard subject.	2.78	2.66	
If I had a choice, I would not study science at school.	1.70	1.59	
I have always been interested in science.	3.93	3.99	
The geosciences are interesting.	4.12	4.48[3]	0.67
The geosciences are fun.	3.84	4.41[3]	0.90
The geosciences are important.	4.14	4.56[3]	0.68
The geosciences are hard.	3.05	3.06	
The geosciences are useful.	4.22	4.52[3]	0.51
Geoscientists are well paid.	3.34	4.38[3]	1.46
Geoscience is a respectable career.	4.15	4.53[3]	0.61

[1]1 = strongly disagree, 2 = disagree, 3 = I don't know, 4 = agree, 5 = strongly agree.
[2]Indicates statistically significant $p < 0.05$.
[3]Indicates $p < 0.001$. Effect size: 0.2 = small; 0.5 = medium; 0.8 = large.

high-level research institution. It is also worth mentioning that we know of one additional participant from the 2002 cohort who earned a master's degree in the geosciences and is currently employed by a major oil company.

DISCUSSION

The results from this study clearly show a positive correlation between participation in the Pathways program and retention of a group of underrepresented minority participants in the geoscience pipeline. The results are significant for the geoscience education literature for a number of reasons. First, they provide a link between short-term indicators of positive attitudinal changes over the course of a summer program to long-term behaviors. Ten years of data show that the choice of college major on the part of high school students who are relatively well prepared in math and science, but know relatively little about the geosciences, are likely swayed by participation in a summer program. Few students entered the program with any formal education in geosciences after middle school (Table III). Yet, 20% of respondents to longitudinal surveys chose geosciences as a college major and 55% chose STEM majors, thus remaining in the geoscience pipeline.

These data also indicate that the summer program is indeed an effective strategy for attracting underrepresented minorities into the geosciences, as over 80% of the participants were of an ethnic minority and over 50% were women. While we did not collect data from participants about either socioeconomic status or status as a first generation college student, we know it is likely that most of the participants were of relatively low socioeconomic status and would likely be the first in their families to graduate from college. This inference comes from census data that show that El Paso County has a median household income of $40,157, and a 23.3% poverty rate. Further, only 20.7% of El Paso County residents have bachelor's degree or higher as their educational background (United States Census Bureau, 2014). Thus, these results may also have implications for the success of programs for participants with these demographic attributes.

The results from the Pathways program are comparable to those of GeoFORCE, the only other summer program in the Geosciences with a similar compilation of longitudinal data (e.g., GeoFORCE, 2014). This program, which marked its 10th year in 2014, has engaged over 1,500 students, of whom 80% were part of minority populations. Of the GeoFORCE participants who are enrolled in or graduated from college, 62% are in STEM majors and 27% are in geoscience majors (e.g., GeoFORCE, 2014). Significant differences between Pathways and GeoFORCE are in program structure and investment. For example, GeoFORCE engages students every summer for four years, and has an

TABLE VII: College attendance of program participants.

	Number of Respondents ($n = 86$)	% Respondents
Attending UTEP	39	45%
Attending EPCC	16	19%
Attending another 4-year college	31	36%

TABLE VIII: Declared college major of program participants.

	Number of Respondents ($n = 86$)	% Respondents
Engineering	13	15%
Geology	17	20%
Science	17	20%
Other	39	45%

annual operating budget of $1.8 million. Results from Pathways suggest that significant improvements in the enrollment of underrepresented minority students in geosciences majors can still be attained for relatively modest investments. The average annual budget for the summer program was less than $50,000, including stipends for students and teachers, grant coordinator salary, graduate student support, transportation, supplies, t-shirts, and posters and brochures.

The 20% and 27% yield of geoscience majors for the Pathways and GeoFORCE programs significantly exceed the national numbers for underrepresented minorities in the geosciences. For comparison, 2012 Integrated Postsecondary Education Data System (IPEDS) data show that just over 9% of bachelor's degrees in the geosciences are awarded to underrepresented minority students (Wilson, 2014).

Recently, Stokes et al. (2013) have argued on the basis of a critical incidents study that few Hispanics enter the geosciences in part because they are much more likely to encounter familial resistance and less likely to have participated in informal outdoor experiences than are white students. In light of the data presented here, results of other summer geoscience programs, and interesting data on parental attitudes present by Houser et al. (2015), we argue that there is strong evidence that summer programs can reverse the effects of these factors. Summer programs can provide both awareness building for the parents and the outdoor experiences for the students needed to overcome the family influences, cultural differences, and hidden barriers in order to increase the likelihood that underrepresented minority students will continue on into the geosciences in college.

CONCLUSIONS

Although the Pathways to the Geosciences Summer Program is no longer running due to lack of funding, the data presented here show that it is was a very effective strategy for inspiring interest in and recruitment into the geosciences among Hispanic American high school students with a strong interest and ability in math and science. Data from our program's pre- and postparticipation surveys showed statistically significant positive changes in attitude towards science and, more specifically, the geosciences. Longitudinally, the data show a positive effect from the Pathways program with retention of participants in the geoscience pipeline.

Some of the key elements from the Pathways program that we believe contributed to its success were: (1) the local, accessible geology that surrounds the El Paso region; (2) exposure to the UTEP campus; and (3) the opportunity to interact with UTEP faculty, the program coordinator, and graduate students, many of whom were Hispanic.

The Pathways program was one element of a geosciences network that the UTEP Department of Geological Sciences sought to build in El Paso in order to (1) increase the number of Hispanic American students who attain bachelor's, master's, and doctoral degrees in the geosciences leading to geoscience careers, and (2) increase awareness of the geosciences as an important and relevant scientific discipline with many career opportunities. Other elements included the work with high school teachers, a research experience for undergraduates, and support for graduate student research.

In thinking about the future of attracting underrepresented minority students to the geosciences, we see the building of networks as an important next step. In El Paso, a few Pathways participants eventually moved into a research experience for undergraduates in geosciences (Carrick, 2014). Networking with the community college professors has also been effective (Doser and Villalobos, 2013) in bringing students into the four-year program at UTEP. These experiences are very much in line with a major recommendation of the recent NRC report, *Preparing the Next Generation of Earth Scientists* (NRC, 2013), that networks that link people and programs are especially important for attracting and retaining students from underrepresented groups. Effective summer programs are only the beginning.

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APPENDIX A

Teacher-partners were important to our goal of building a geosciences pipeline because they reach high-school aged students in ways that UTEP faculty do not. For the teachers, a major objective of the program was to demonstrate to them how geoscience activities and lesson plans can be seamlessly integrated into the scope and sequence of high school biology, chemistry, and physics courses required by the State of Texas.

Our recruitment tactics for teachers followed those for student recruitment. As the program progressed, the coordinator contacted previous teachers to ask if they would speak with other teachers they felt might be interested in the program or to suggest a teacher we could contact.

The only criteria for the teachers were that they were teaching science or math at the high school level. Unlike the student applications, the teacher applications were sparse. Most years we received between six and eight applications. Participating teachers were given a $3,000 stipend (paid in $1,000 increments: summer, fall, and spring), and $300 for supplies for the following year.

Upon selection, the teachers attended a meeting that outlined the requirements and commitments to the program. These included:

- Participation in a two-week program session.
- Development of two signature lessons during the summer camp session to use during the regular academic year.
- Integration of geological concepts and applications into daily lesson plans by producing one signature lesson each six weeks during the fall and spring semesters in collaboration with Pathways staff.
- Permission for UTEP faculty or staff to participate in and observe at least three class meetings per semester.
- Permission for UTEP faculty or staff to distribute and collect surveys and/or data from the teacher and the students in the high school classroom
- Permission for UTEP faculty or staff to invite other educators to the classroom to observe a class in which they integrate geosciences into the curriculum.

Meaningful longitudinal interaction with teachers was the least successful aspect of the program. During the summer session, teachers participated actively and provided us with valuable information and insight into how program activities could make a strong impact on students. During the regular school year, however, we found it very difficult to communicate with and engage the teachers.

Group meetings were nearly impossible to schedule. At the few meetings we were able to arrange, the teachers indicated they lacked the time to write new lessons or have us observe in their classroom. While some teachers did fulfill their commitments to the program, the majority did not. As a result, our goal to develop multiple geoscience lesson plans that met state standards and that would be potentially shared with many other high school teachers was not achieved. Our conclusions are that a very different program structure, one that includes a much greater investment of time and effort than we had the resources for, is probably what it requires to systematically advance science teachers' integration of geoscience topics into their lesson plans.