Geosciences Awareness Program: A Program for Broadening Participation of Students in Geosciences

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ABSTRACT

The Geosciences Awareness Program (Project GAP), a collaboration between the Ohio State University and Columbus State Community College, was designed to broaden the participation of underrepresented groups in geosciences at both precollege and college levels. As part of Project GAP's precollege initiative, students at five predominantly minority schools in Columbus, Ohio, were introduced to Project GAP's objectives through presentations and related hands-on activities. The methods developed through Project GAP for enhancing precollege students' attitudes toward, and increasing their interest in, geosciences included showing the relevance of geosciences to society, highlighting the salary outlook for geoscientists, and providing examples of distinguished minority geoscientists. The effectiveness of the GAP model for increasing the number of future geoscientists was supported by data collected through pre- and postpresentation surveys of participants. © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/10-208.1]

Key words: geosciences, diversity, precollege initiative

INTRODUCTION

Demographic studies predict that there will be significant changes in the population of the United States in the coming 40 to 50 years. By 2050, a large proportion of the population will originate from the currently underrepresented African American, Hispanic American, and Native American groups (U.S. Census Bureau, 2008). However, most of these groups are underrepresented in science, technology, engineering, and mathematics (STEM) fields (National Science Foundation, 2009).

A recent report by the Higher Education Research Institute (2010) at UCLA suggests that parity now exists in the percentage of students interested in STEM fields by race and ethnicity. However, the completion rate of bachelor's degrees by underrepresented minority students after 4 or 5 years in STEM fields is still very low when compared to rates for white and Asian students (Higher Education Research Institute, 2010). In order to remain competitive on the world stage and in the global economy, the United States must develop a robust scientific workforce by developing intervention programs that increase the participation of underrepresented students in STEM fields and encourage these students to choose STEM subjects as their major field of study. Several programs have been developed to improve underrepresented minority group participation at different academic levels. These programs include the Meyerhoff Scholars Programs (Hrabowski and Pearson, 1993; Maton and Hrabowski, 2004), the Louis Stokes Alliances for Minority Participation (LSAMP; 2005), the National Consortium for Graduate Degrees for Minorities and Science and Engineering (GEM; 2006), and National Institutes of Health (NIH) Minority Research and Training Programs (1993).

Geosciences face a more difficult challenge than many other STEM initiatives because of their lack of visibility to many underrepresented precollege students, and because of these students' lack of exposure to the geosciences early in their academic training (Fields, 1998). Successful strategies for increasing the participation of underrepresented minority students in the Earth sciences include mentoring and making geosciences relevant to society (Huntoon and Lane, 2007), applying theoretical and practical approaches to geosciences projects (Levine et al., 2007; Orion et al., 2007), creating social connections to facilitate inclusion of underserved communities (Pandya et al., 2007; Hanks et al., 2007), and involvement of local institutional administration in the projects (Robinson et al., 2007). It has also been proposed that a strategy for diversifying the geosciences workforce should include multiagency collaboration that is focused on addressing generational differences (Velasco and De Velasco, 2010).

Project GAP is designed to develop underrepresented minority students' interest in majoring in geosciences through precollege and college initiatives. The precollege initiative's target audiences are precollege students, teachers, and STEM group advisors. The college initiative's target audiences are undecided freshmen and college seniors with science backgrounds at The Ohio State University, students at Columbus State Community College, and the general public. Through the precollege initiative, Project GAP conducted a "Teach the Teacher" seminar series for local area teachers. The seminars introduced teachers to the mission of Project GAP and provided hands-on activities for precollege students.

The precollege initiative targets five cities within Ohio: Columbus, Cleveland, Cincinnati, Dayton, and Akron. These

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TABLE I: Survey questions administered before and after Project GAP.

Questions	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. I think geological science is really interesting.	☐	☐	☐	☐	☐
2. Geoscientists or Earth scientists are mostly men who work in the field.	☐	☐	☐	☐	☐
3. I might want to be a geoscientist or Earth scientist.	☐	☐	☐	☐	☐
4. I am familiar with what a geoscientist or Earth scientist does.	☐	☐	☐	☐	☐
5. I know a geoscientist or Earth scientist personally.	☐	☐	☐	☐	☐
6. You need to know a lot of math to become a geoscientist or Earth scientist.	☐	☐	☐	☐	☐
7. Women can be geoscientists or Earth scientists.	☐	☐	☐	☐	☐
8. Geoscientists or Earth scientists cannot be trusted.	☐	☐	☐	☐	☐
9. Geoscientists or Earth scientists cannot be religious.	☐	☐	☐	☐	☐
10. My family would be proud of me if I became a geoscientist or Earth scientist.	☐	☐	☐	☐	☐

cities have large numbers of underrepresented minority populations and are close to The Ohio State University in Columbus, Ohio, where Project GAP is housed. The study was carried out at five high schools in Columbus with predominantly underrepresented minority students.

PROJECT GAP METHODOLOGY

Project GAP consisted of a series of PowerPoint presentations and hands-on activities (see supplemental material, Project GAP Presentation, available online at: http://dx.doi.org/10.5408/10-208S1), and was assessed

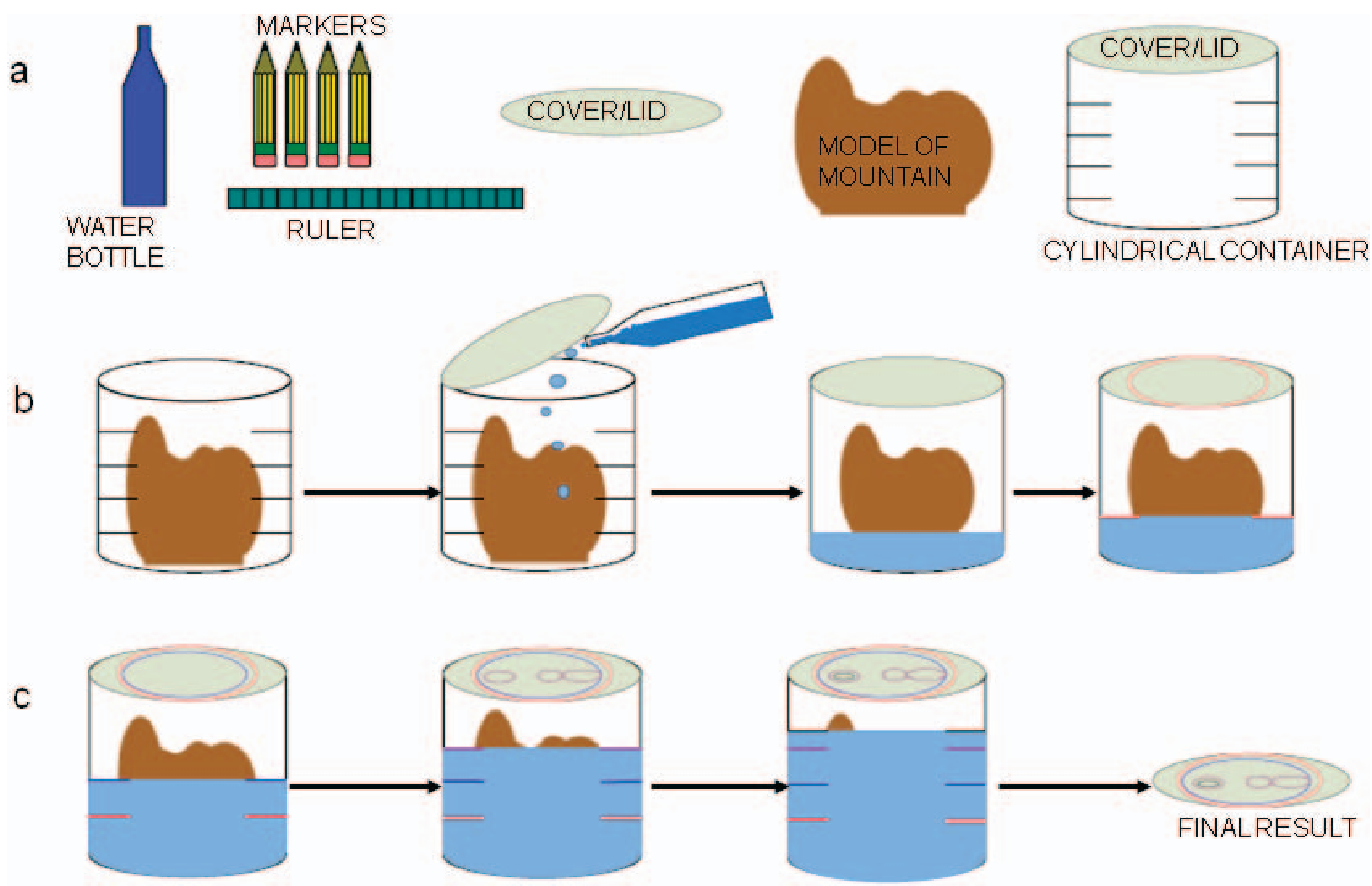

FIGURE 1: Construction of a topographic map hands-on exercise. (a) Materials required. (b) Addition of water to initial level, with trace of model at this level indicated on cover. (c) Addition of water to different levels, with traces of model at each level indicated on cover, followed by final result.

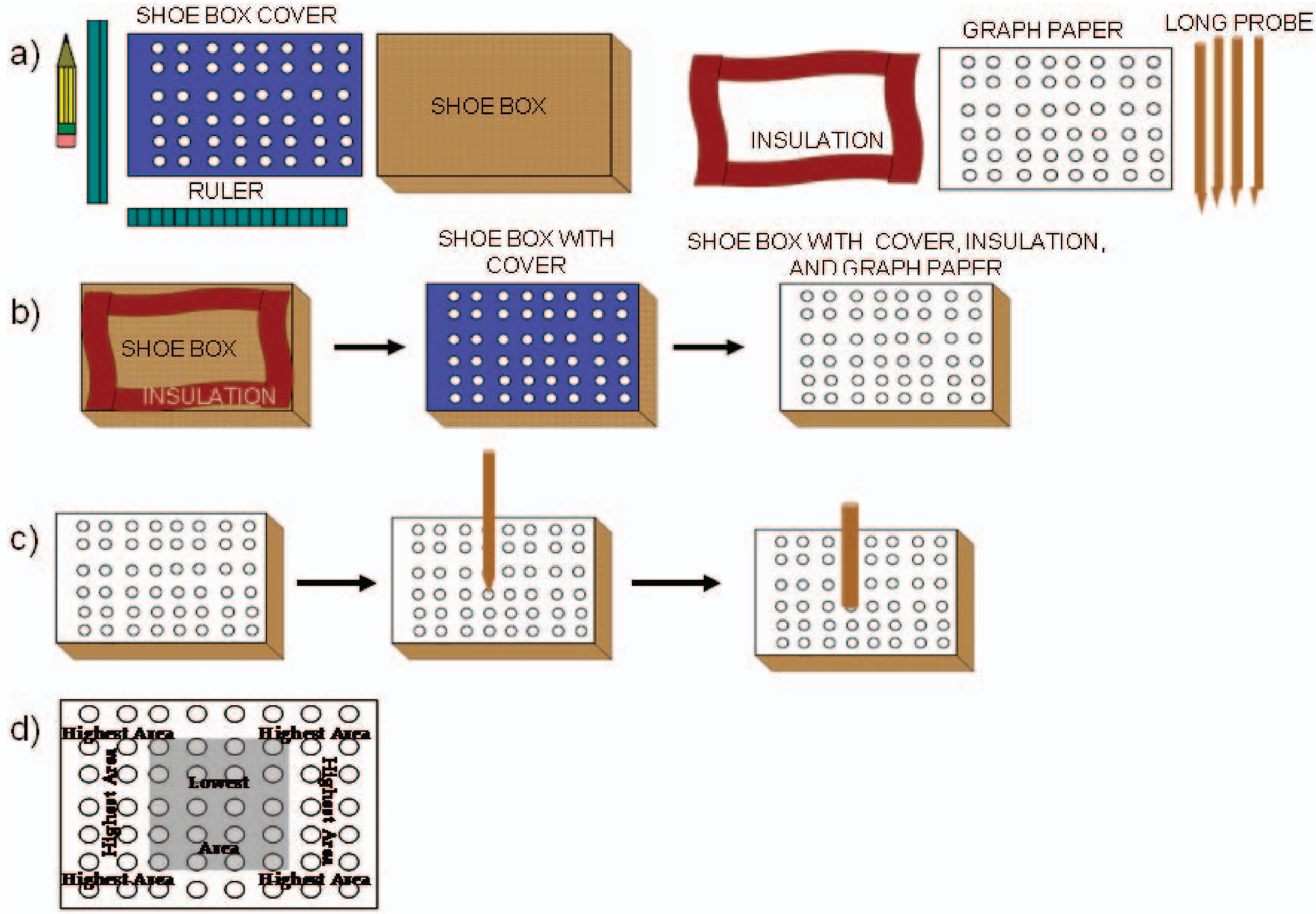

FIGURE 2: Exploring an unknown surface hands-on activity. (a) Materials for constructing the unknown structure hands-on activity. (b) Image progression of the material being placed inside a shoe box. (c) Sealed box containing unknown (insulating foam) structure covered with graph paper and the box being probed. (d) Top view of the graph paper showing the final result, with the highest and lowest areas of the unknown structure identified.

through administration of questions to students in pre- and postparticipation surveys. The survey questions were based on items used by Kitts (2009). First, students completed the preparticipation survey (Table I). Then the topics (Table IIA) were presented to the students. Finally, each topic was presented in detail, and a postparticipation survey was completed by participating students.

Presentation Topics

Targeted questions

Each presentation started by asking the students 10 targeted questions (Table IIB). An affirmative answer to any of the questions was intended to raise the student's interest and engagement in the Project GAP discussions and activities.

Overview of the Message Delivered to the Students

Earth science (also known as geoscience, the geosciences, or the Earth sciences) was presented to our audience as an all-embracing term for the sciences related to Planet Earth. Geoscience provides opportunity for exploration of the outdoors while building a quantitative understanding of how the Earth system works and how it evolved to its current state. Emphasis was made on the richness of the geosciences that comes from the diversity of science backgrounds and specialties within the field. We also highlighted the contributions of geoscientists to finding solutions to our energy problems and protection of our environment.

The diversity in gender and ethnicity of current geoscientists was discussed with the students. Pictures of some distinguished geoscientists from underrepresented minority groups who are chairs of geoscience departments in major, well-established research universities, and others who are currently employed in high-profile positions in major oil and gas companies, were shown. Students were also presented with information about the wide variety of job opportunities for geoscientists in the private and public sectors. Some of the prospective workplaces mentioned in the presentation included the oil and gas industries, federal government laboratories (including the National Laboratories), the United States Geological Survey, the State Geological Surveys, the mining and mineral industries, the Department of Energy, and academia.

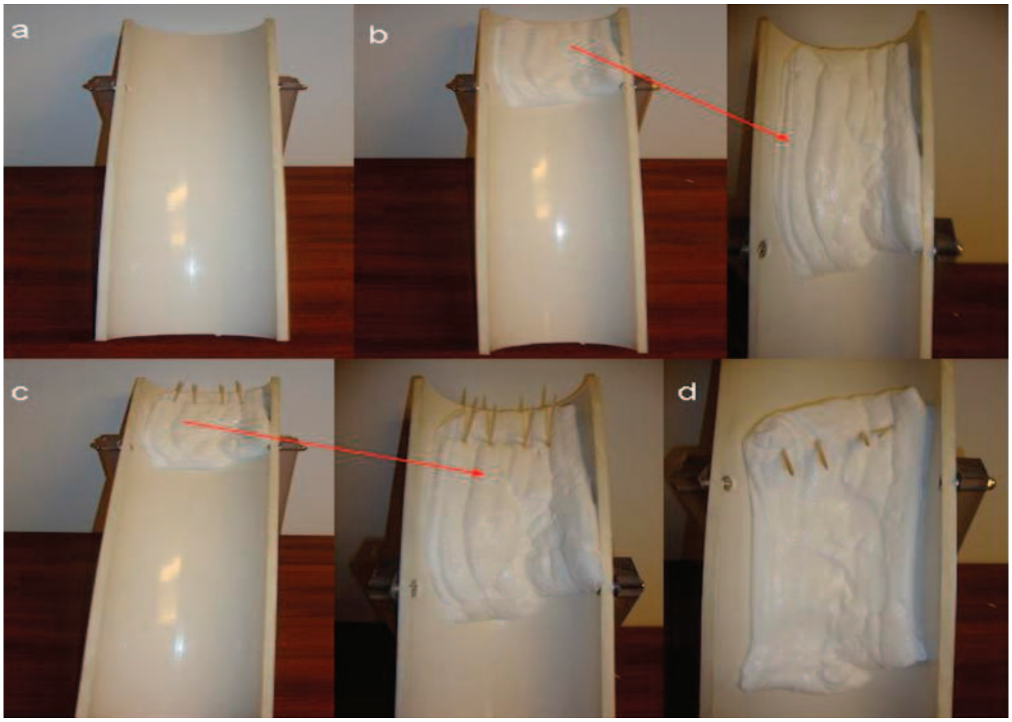

FIGURE 3: Glacier dynamics hands-on activity. (a) Activity setup. (b) Flubber added; change over time. (c) Toothpicks added to flubber to serve as markers; change over time. (d) Changes in toothpicks and flubber over longer period of time.

The students were shown the 2008–2009 Geological Salary Survey data from the American Association of Petroleum Geologists (AAPG) Explorer (2009). The discussion about geoscientists' salaries elicited more student questions and comments than any other discussion topic. Based on the response we observed among these students, information about geoscientists' salaries and the increasing demand for geoscientists appears to be an effective way to engage precollege students and interest them in geosciences careers. Following the discussion about salaries, questions about the requirements to get into the field of geosciences were addressed. Students were told about the importance of math and science. We then presented hands-on activities, involving constructing topographic maps (Fig. 1a–c), exploring an unknown surface (Fig. 2a–d), and studying the dynamics of a glacier model (Fig. 3a–d). After the topographic maps activity, students were encouraged to explore topographic maps online by using either the Google Maps or Google Earth websites. Students were encouraged to explore different regions of the Grand Canyon on either http://maps.google.com/ or http://earth.google.com/.

In the unknown-surface activity, students were asked to measure the depth to the bottom of a partially filled shoe box using a long probe (a skewer), and then to record their measurement on a data sheet or graph paper (Fig. 2a–d).

TABLE IIA: Project GAP presentation projects.

1. Selected and targeted questions exercise
2. Definition of geosciences
3. Earth composition and structure
4. What do geoscientists do?
5. Who are underrepresented geoscientists?
6. Where do geoscientists work?
7. Prospective employers
8. Salary outlook for geoscientists
9. Relevance of geosciences to society
10. Hands-on activities

TABLE IIB: Targeted questions (presentation topic A).

1. Do you want to know why earthquakes happen?
2. Are you interested in traveling around the world and exploring the oceans?
3. Do you want to protect our environment?
4. Do you want to learn about global warming and climate change?
5. Are you interested in contributing to solving our energy problem?
6. Do you want to contribute to the development of new technologies?
7. Do you want to make a difference in society?
8. Are you interested in finding clean water for all global citizens?
9. Are you interested in learning about our Earth?
10. Are you interested in understanding the origin of volcanic activities?

NOTE: Some questions modified from EarthScienceCanada, (2008).

TABLE III: Demographic characteristics of Project GAP participants.

	African American	Hispanic	Asian	Other*	White	Total
Male	61	2	2	1	1	67
Female	11				7	18
Total	72	2	2	1	8	85

*The other respondent was a foreign national.

Several measurements were made by probing the unknown surface inside a shoe box at different regions. The depth of each region of the unknown surface was recorded on the graph paper. At the end, students were asked to find the lowest and highest points based on their measurements. This activity modeled what geoscientists do when exploring the ocean floor.

The glacier dynamics activity (Stearns and Hamilton, 2003) entailed asking students to determine the velocity of a glacier as a function of different parameters (Fig. 3a–d). The glacier models (made of flubber[1]) were probed at different temperatures, slopes, and basal conditions to determine how the speed of the flubber changes as a result of these conditions.

EVALUATION METHODS

Pre- and postparticipation surveys were administered to 85 students participating in Project GAP. The demographic characteristics of the 85 participants are given in Table III. Seventy-one students completed both the preparticipation and postparticipation surveys. Completion of the surveys by the students was voluntary. Survey items (Table I) used a five-point Likert-type scale. Agreement was treated as if it were a continuous variable. Responses were coded as follows: strongly agree (4), agree (3), undecided (2.5), disagree (2), and strongly disagree (1).

Mean response scores were calculated for each preparticipation and postparticipation question for the 71 students responding to both questions. Within-student change scores were calculated. The significance of the change scores was determined with two-tailed dependent *t*-test. (Complete statistical data available in Supplemental Table IV available online at: http://dx.doi.org/10.5408/10-208S2.)

RESULTS AND DISCUSSION

Figure 4 shows the 71 underrepresented minority students' average responses to the survey questions. Data from Question 1 (Q1) show that the interest of the students in the geosciences increased after they participated in Project GAP ($p = .015$). Data from Q2 shows that after participation, students were more likely to disagree with the statement, *"Geologists or Earth scientists are mostly men who work in the field"* ($p = .002$).

Students were more likely to agree with the statement, *"I might want to be a geoscientist or Earth scientist"* after participation ($p < .0001$). Their average response increased from a level indicating disagreement (1.98) to a level that, on average, was nearly neutral (2.46). There was a substantial impact on quite a few students: Prior to participation, 19 students strongly disagreed with this statement. After participation, only 8 strongly disagreed. Conversely, prior to participation, only one student agreed and only one other student strongly agreed that they might want to be a geoscientist or Earth scientist. After participation, 21 agreed and 4 strongly agreed. This strongly suggests that there is an increase in the desire to become a geologist after participation in Project GAP's intervention.

There was a marginally significant increase in students' knowledge of what geoscientists do ($p = .065$), and a statistically significant increase in students' reporting that they personally knew a geoscientist ($p = .032$). For the remaining questions, the data did not show any statistically significant changes. This might be partly due to the nature of the questions asked and how they were presented. For example, both prior to participation and after participation, nearly everyone agreed that *"Women can be geoscientists or Earth scientists."* Only two people disagreed with this statement prior to participation and only one disagreed after participation. This may be an example of a ceiling effect: Given the very high baseline response, there simply was not much room to show statistically significant improvements.

It is good to know that most students felt that their family would be proud of them if they become geoscientists (Q10), indicating the majority of parents would be proud to see their children earn a higher education degree in geosciences. This is similar to data reported by Kitts (2009) in surveys of 2,535 middle and high school students in northern Illinois about their attitudes about science. It is also noteworthy that most students believed that it was necessary to know a lot of math and science to become a proficient geoscientist. This result is similar to the findings of Kitts (2009) and Furner and Duffy (2002), who proposed that students have an exaggerated view of the amount of mathematics they need to know to do well in science. Correcting this misperception in the future will help to increase the size of the pool of students interested in potential careers in the geosciences.

CONCLUSION

Analyses of pre- and postparticipation survey responses indicated statistically significant increases in students' attitudes toward and interest in geosciences. With any kind of self-reported survey data, questions can be raised about possible sources of bias. We think it is unlikely that students provided responses that they felt we wanted to hear: If this

[1] Flubber is a rubbery polymer formed by the cross linking of polyvinyl alcohol with a boron compound. The flubber used for the Glacier Dynamic activity was made from a polyvinyl alcohol-based glue (Elmer's Glue) and borax (a boron-based household detergent). The recipe used here is given in Stearns and Hamilton (2003).

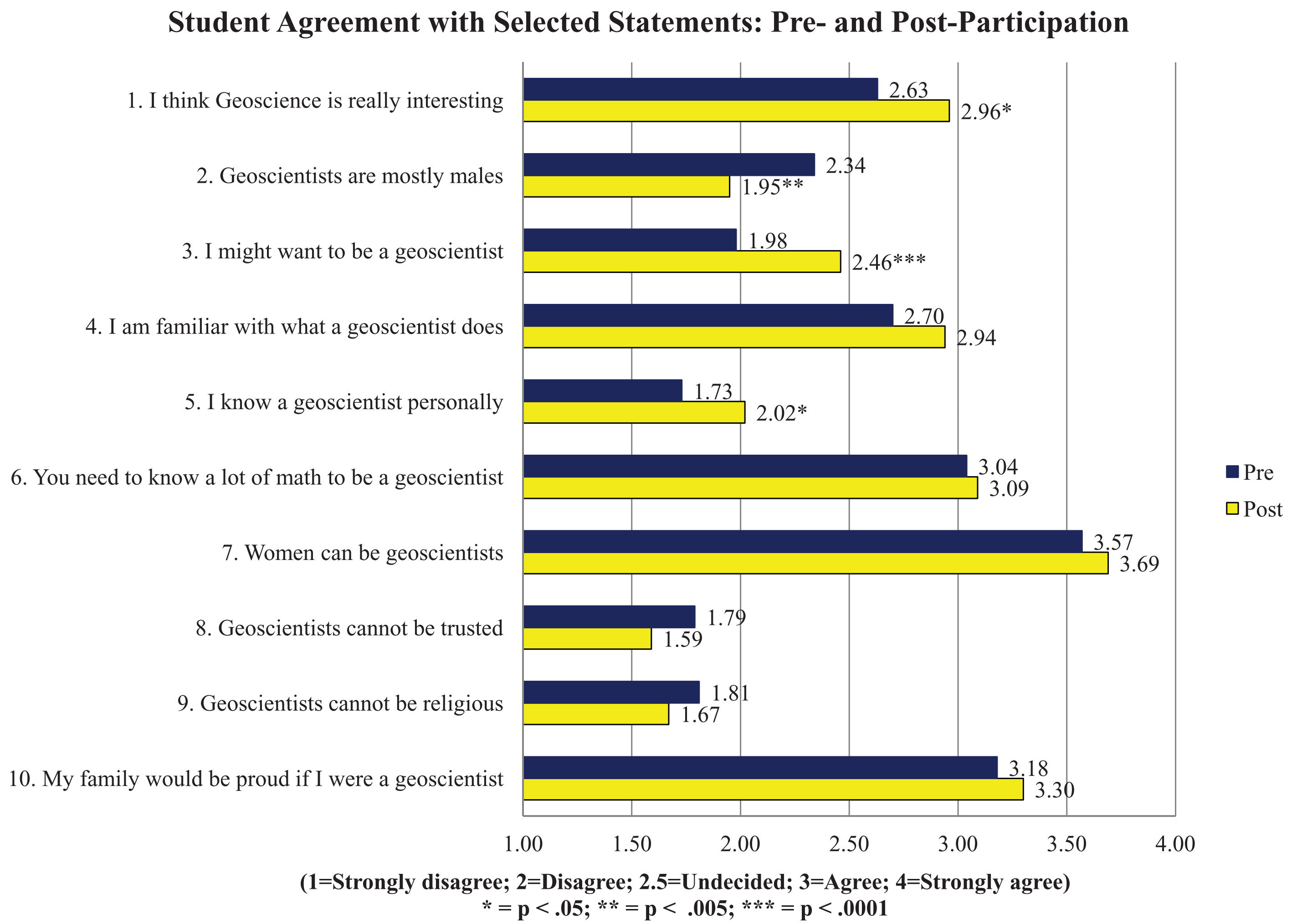

FIGURE 4: Student responses to Project GAP attitude survey questions 1 through 10.

were the case, one would expect to find significant improvements in all of the attitudes that were assessed, rather than in only 4 of the 10 attitudes being measured. We believe these statistically significant results are a reflection of true changes in participants' attitudes and beliefs. We thus interpret the intervention model developed through Project GAP as being effective and potentially transportable to other underrepresented minority student populations.

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