International Journal of Environmental & Science Education
Vol. 3, No. 3, July 2008, 131-141

A Science Summer Camp as an Effective way to Recruit High School Students to Major in the Physical Sciences and Science Education

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Received 14 May 2008; Accepted 16 June 2008

Now in its fifth year, PR^{2}EPS is a National Science Foundation funded initiative designed to recruit high school students to attend college majoring in the physical sciences, including engineering and secondary science education, and to help ensure their retention within these programs until graduation. A central feature of the recruitment effort is a free, one-week residential summer science camp for high school students. This report describes the rationale for using a camp as a recruitment tool as well as the camp structure. Two focus questions are addressed: 1) How successful is the camp at providing a learning environment where participants can share their enthusiasm for science and brainstorm and apply solutions to challenging scientific tasks with their peers? 2) How successful is the camp at recruiting students into the physical sciences at this college? Quantitative data from pre- and post-camp and longitudinal surveys showing that campers are pursuing degrees in the sciences are substantiated in a framework of qualitative data collected during the summer of 2007 by a non-participant observer. Faculty similarly concerned with motivating high school students to major in the physical sciences and science education should find the report useful as several indicators show that most campers continue on their trajectory towards degrees in the sciences.

Key Words: learning environment, motivation, physical science, science camp

Introduction

Increasing the number of undergraduate students obtaining degrees in science, technology, engineering, and mathematics is the main focus of the National Science Foundations' (NSF) Science Talent Expansion Program (STEP). The rationale in support of the program is that the United States' economy, and the overall quality of life and standard of living of its citizens are dependent on a scientifically and technologically trained workforce (National Science Foundation, 2007). Because the current supply of highly qualified scientists and science teachers is not meeting the societal demand, alternative pathways to teacher certification, especially for highly trained scientists are being created (e.g. Denton, Davis, 2007).

Press announcements and research reports grounded in statistical data from science achievement studies have been alarming. The 2005 National Assessment of Educational

ISSN 1306-3065

http://www.ijese.com/

Progress (NCES, 2006) reports that average science scores in 2005 are higher at grade 4, unchanged at grade 8, and lower at grade 12 now than they were in 1996. Although there has been some slight improvement among the younger students, the performance of our high school students is worse now than it was ten years ago. Other studies (e.g., Moore, 2001) have also described a distressing decrease in both the quality and quantity of domestically trained science students in the U.S. As reported by Moore, the National Commission on Mathematics and Science Teaching for the 21st Century has pointed out that U.S. children are not performing to their potential in science.

The unacceptable performance of science students in the U.S. and potentially other countries is due at least in part, to a demonstrable lack of motivation to study science because of poor self-perceptions of their ability and a strong disconnect between school science experiences and the lecture and listen nature of the learning environment (e.g., Bauer, 2002; Howell, 1999). A few researchers have taken the question of why students are disengaged from science even further. For example, a study by Basu and Calabrese Barton (2007) found that high poverty urban students' sustained interest in science was connected to how they envision science experiences as being relevant to their futures, and by learning science in socially constructive learning environments. A longitudinal study conducted by Simpkins, Davis-Kean and Eccles (2006) found that the quality and frequency of children's out of school science activity participation was predictive of their science values and in turn, the number of high school science course they chose to enroll in.

One thing is certain, the day-to-day quality of life, and the ability of the youth to serve the world's growing humanitarian and social needs relies on their technological and scientific capacities. In this sense, it is imperative that strategies designed to motivate involvement in the sciences and then foster success need to be aggressively developed, and the results need to be reported to all stake holders in the education community.

Funded in 2003 with a grant from the National Science Foundation, a team of five college faculty from a public upstate New York college set out on a five year project named PR^{2}EPS-Preparation, Recruitment, Retention and Excellence in the Physical Sciences, designed to recruit high school students to attend college majoring in the physical sciences and science education and to help ensure their retention within the program until graduation. The central feature of the recruitment effort is a one-week summer science camp for high school students. The camp is completely free for the students who reside on campus during the week, and high school students who attend the camp and subsequently enroll in this college as science or science education majors receive a one-time $1000 scholarship. As of fall 2007, we have held and evaluated four successive summer camps with 176 total campers. Other aspects the PR^{2}EPS program are indicated in Figure 1.

This paper describes the structure of the summer science camp only and addresses two main assessment issues:

1) How successful is the camp at providing a learning environment where participants can share their enthusiasm for science and brainstorm and apply solutions to scientific challenges with their peers?

2) How successful is the camp at recruiting students into the physical sciences at this college?

Rationale for using a summer science camp as a recruitment tool and staffing

The utilization of science camps to motivate students and show them that they have the ability to become scientists has been supported by (NSF, 1994) and is in the science education literature (e.g., Cavallo, Sullivan, Hall and Bennett, 1999; Exstrom and Mosher, 2000; Robbins and Schoenfisch, 2005). If a camp program is well organized, technically challenging and engaging, a high school student's participation in the scientific and sociological components of a summer science camp may serve to consolidate his/her interest in pursuing science in college.

The PR^{2}EPS camp runs for one-week, is staffed by five college faculty, about eight selected college science majors and usually one or two high school science teachers, a professional lab or non academic scientist and a camp nurse. The ratio of campers to adult staff is near 3:1. The camp is licensed under the regulations of the NY State Department of Health Children's Camps guidelines.

Recruiting the campers

Because the PR^{2}EPS science summer camp is meant to be an exhilarating science experience and ultimately further motivate high school students to enroll in college as science majors, we strongly encourage average high school students to apply for the camp. That is, we are not necessarily interested in encouraging students who have already chosen science as a career path to attend the camp. Our target group is 11th graders who have not yet decided what to study in college.

During the academic year, the college faculty operating the program schedule visits with high schools within a 70 mile radius of the campus and gives a fifteen-minute recruitment talk, mostly in the 11th grade science classes. During the recruitment talk, the students are shown slides from previous camps, and are provided information about the PR^{2}EPS program; including the impact that participation may have on their college admissions and professional careers, and the fact that all those who participate in the camp, and subsequently enroll at the college as science majors will receive a one-time $1000 scholarship. Typically the team speaks in 15 high schools each year and to about 500 students. Immediately following the talk interested student are directed to where they can apply for the camp. In addition, the camp has been featured on local radio several times and the focus of several local newspaper columns. We also advertise the camp in local papers.

Each year our goal is to accept about 45 students. For the first two years, every student who applied to the camp was accepted and the camps operated with 35 and 37 students. About 100 students applied for camp in year 3 and we accepted 55 campers. We had a similarly strong response in 2007 and accepted 45 campers, turning down more than a dozen qualified applicants. In terms of recruitment, the program has clearly gained momentum.

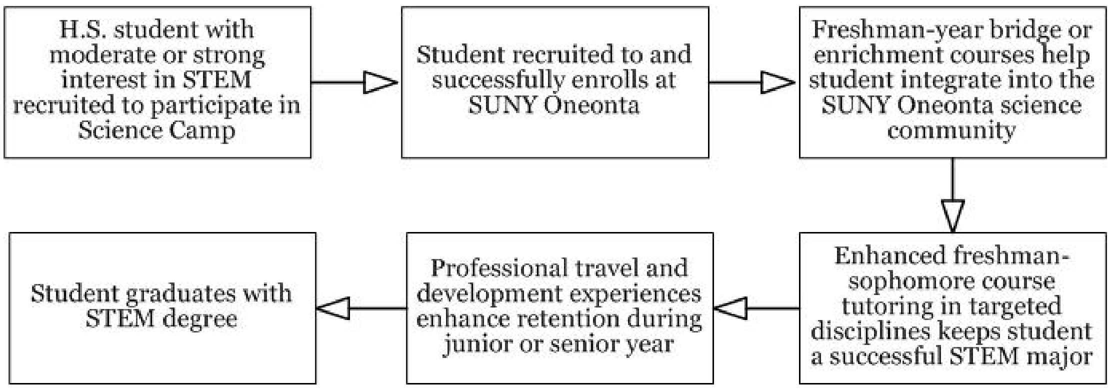

Figure 1. Flow model of PR^{2}EPS program.

Investigative teams

Camp participation emphasis teamwork, cooperation, and creative problem solving when faced with scientific and engineering challenges. To facilitate this atmosphere, we form the campers into scientific investigative teams prior to their arrival. The teams consist of about four campers, lead by a councilor who is normally a college science major or high school science teacher. Teams are mixed gender with students from different schools on the same team to encourage the formation of new friendships and a cohesive team spirit. The teams work together for the entire week. The councilors are instructed to assist the team in generating solutions to problems. They are instructed not to take charge, or in effect do the thinking or problem solving for the high school students.

Science and social activities

In planning each annual camp, the five-core faculty, explore and tinker with science activities in efforts to identify those most appropriate for the campers. In keeping with the motivational goals of the camp, activities that necessitate problem solving, teamwork, and the application of science skills are selected and form the framework of the camp experience. Primarily, activities that result in a finished product and that can be publicly demonstrated by campers to peer investigative teams are utilized. Each year the schedule of activities is adjusted based on our observations of the campers engagement and data from an end of camp survey where campers identify their favorite and least favorite activities. Additionally, a broad range of topics are selected to meet the interests of the campers.

A copy of a recent camp manual can be found at the PR2EPS website (http://www.oneonta.edu/academics/PR2EPS/). Some of the major activities conducted at each camp include: forensic science with DNA biochemistry and gel electrophoresis; designing, constructing and evaluating the performance of 2-liter soda bottle rockets using software modeling and digital video; constructing boats that can be maneuvered through an obstacle course while being steered remotely; building and riding on hovercrafts; and qualitative chemical analysis of narcotics on currency.

The inaugural one-week 2004 camp schedule had the campers engaged in science activities every morning, afternoon and most evenings. In the end, most were simply exhausted with science by Friday afternoon. This exhaustion with science was evident in their waning enthusiasm and in their responses to the end of camp survey question “What could the staff have done differently to make the experience more enjoyable for you?” Thereafter, we generated camp schedules with a healthy mix of science and social activities. Recent camps featured trips to a semi-professional baseball game, an evening trip to a multiplex movie theatre, a night of astronomy using the campus telescopes, a dance night, nature hikes, volleyball, soccer matches and some free time simply interspersed within the academic schedule. As a result, the campers engaged socially with each other, the college student scientists and the college faculty and there have been noticeable increases in the overall enthusiasm to do the science activities.

Interestingly, the increased social time was not at the expense of less science. The increased energy and enthusiasm catalyzed greater science participation. It is also believed that this arrangement may lead to reducing artificial social barriers between campers (and college student scientists who are our staff) and faculty members. Greater communication and an ability to more readily and openly communicate across these groups may assist campers in their future collegiate careers, regardless of their major or institution.

Camp assessments

We have several forms of assessment in place and these have evolved with our experience. Accessible from our website is a self report Camper Alumni Survey. We use this data to obtain longitudinal follow up information on campers' perceptions of how the camp has influenced their academic choices and what they are currently majoring in if in college. We used only pre and post camp surveys, administered during the camp, in summer 2004. These were developed by reviewing the literature on attitudes towards science, self perceptions and science interest inventories. Surveys and the presence of a non-participant external evaluator who specializes in educational evaluation was hired for summers 2005 and 2006. The reports written by this evaluator were invaluable in our steering the camp towards its current position. And, in an effort to bring new insights, for summer 2007 we recruited a non-participant evaluator from within our own college, who specialized in mathematics education and who is responsible for the research component of our masters in education programs. Working in consultation with the PR^2EPS team, we developed a data collection strategy consisting of both quantitative and qualitative measures prior to the start of the 2007 camp. The evaluator, participated in the entire camp, beginning with the staff training session Sunday afternoon, continuing through Friday afternoon when the camp ended. Quantitative data consisted of pre-post camp surveys designed to assess campers' interest in science, attitudes towards science, self-perception of science skills, and interest in studying science in college.

Qualitative data was collected at the end of three major activities (i.e., the rocket activity, the boat activity, and the environmental-geology field trip) by requiring the campers to respond to two open-ended questions after each activity. Additionally, evaluators took field notes on what the students were doing while engaged in the science activities and interviewed several students as the camp progressed about how the camp experience was impacting their future goals. The data used in this report comes from all sources but draws most heavily on the alumni survey and some of the qualitative data gathered during the 2007 camp.

Results

The first goal of the camp is to provide an environment where participants' can share their enthusiasm for science and brainstorm and apply solutions to scientific challenges with their peers. The qualitative data collected (in the form of student written reflections and student interviews after each major activity) provides a more in-depth look at the power of the science camp experience. The following student voices are shared in an attempt to reveal the full quality of the camp experience. Note that each activity's reflection consisted of two questions: the first question related to science content and inquiry process; the second question pertained to the sociological impact and the campers' perceptions of the scientific process.

First activity - rocket design and launch

Day 1, Reflective Question 1: "*What parts did you like about today's activity?*"

- Teamwork because I like to work with others. Also I liked launching the rockets. Overall the creation of the rockets and the problem solving that went into making them was interesting. The best part of this was that we had a basic computer program to help us in the creation of our rockets. Using this, we got our rockets to go as far as possible.

- I thought the activity helped me understand how much rocket scientists have to observe their rockets. I especially liked the video analysis because that helped me reevaluate and improve upon my rocket. I also liked how available the high quality materials were for this project.
- Launching our rockets in the field and seeing the other groups' ideas. This helped us see what modifications we could make to our own rocket. I also thought that learning how to prepare the launch pad was a good way to understand how the pressure in the bottle propelled the rockets.

Day 1, Reflective Question 2: "*How many times did you re-think or re-evaluate your steps in working on today's task?*"

- We tried several different things on our rockets and before we made any changes, we talked about it and thought up different ideas for fins, shape, etc. Once we did the first launch, we knew we needed to add weights. We decided where to add it and how much and we determined the correct values using the program.
- We re-evaluated our steps twice. After we saw which designs worked better than our own we thought of new ways to modify it. Our main correction was the weight factor. We had too much weight and not enough water.
- I reevaluated my steps about 8 times. One time, I reevaluated how much weight was in the nose of the rocket. I decreased the weight in the nose by taking out a large amount of foam in the nose. This helped the rocket reach maximum distance.
- I liked the first day of the project where we designed the rockets. This is because I like the design aspect of the process.

Second activity – boat design and navigation

Day 3, Reflective Question 1: "*Were you, as an individual, able to make contributions to the group? In what ways?*"

- Yes, I was. I helped in the designing of the boat and I drew out all the different possibilities. We then eliminated some options as a group. I also helped cut the plexiglass with scissors, and had the idea of making slits to connect them together.
- Yes, I cam up with several suggestions for modifications to our boat. I built the battery controls and helped a lot to balance the boat. Also I helped to finish the rudder, flippers and all the finishing touches.

Day 3, Reflective Question 2: "*What's one good idea you learned from a group member in successfully working on today's project*?"

- The best way to solve a problem is to brainstorm. And when building the model to continuously revise the original plan.
- To think outside the box, for example, to put the paddle in the front, not the back, which was very successful for our team.
- Fragment the tasks to get it done faster. Duct tape over all of the electrical components and over wire connections.
- One good idea was using smaller flippers and using a quick engine. The flippers turned quickly and propelled the boat well. It was Matt's idea and I think that if our

rudder didn't get messed up at the beginning of the race, we could have done very well.

Third activity – environmental chemistry and geologic science state park field trip

Day 4, Reflective Question 1: "*Which of today's activities was a new experience for you? In what ways?*"

- Studying geology. Because I have never had an interest until now in geology. It allowed me to see another part of science.
- Tracking the glaciers. I had never done it before.
- Testing the water in the lake for aluminum, iron and nitrates. It was interesting to see how certain things affect the water quality (e.g., bathrooms, boat launches).

Day 4, Reflective Question 2: "*Describe something you learned from your group during one of today's activities that you may not have learned if you had been working on your own*"

- I learned from Catherine how to set up the machine to test the iron and nitrate. I would never have figured it out on my own.
- How to notice signs of glaciers. With more people, it was easier to find the striations and chattermarks.
- I learned that glacial action is responsible for many physical features of the earth.

Across the three activities, it is clear from the student comments that camp participants were engaged in science content and processes throughout the week, and they were involved in experiences that required team inquiry, creative problem-solving and shared thinking and re-structuring. Through a collaborative involvement with science content, science inquiry and peer exchange, students were engaged in high level thinking as an individual and as a team member.

Comparative analyses of the two questions from the pre and post camp surveys also support the conclusion that the camp is structured in a way that campers learned to value the process of collaborative team work. There was a statistically significant difference ($t = 8.0$; df, 41, $p \leq .00$) in the campers' responses to these two questions. 1. I generally like to work alone on science tasks. 2; I enjoyed working with other high school students in the science activities.

Data addressing the second goal of the camp: "How successful is the camp at motivating the campers to enroll in college as physical science or science education majors?" is shown in Figures 2, 3 and 4. The data in Figure 2 are institutional enrollment data in the physical sciences and secondary science education.

The data are very promising. The secondary science education program has doubled in size since the start of PR^{2}EPS. These increases are due to enrollments in the chemistry and physics education programs-our target disciplines and not biology and earth science education as enrollments in these majors is mostly unchanged. Enrollments in physics and chemistry are likewise increasing and are larger now than at any point in our collective memories. While it is impossible to attribute these positive trends solely to PR^{2}EPS, we do know that 30 former campers are now enrolled in the college and fifteen others have applied for admissions, including several from the 2007 several camp who are awaiting an admissions decision. We have awarded twenty-two $1000 scholarships to former campers. The program is meeting its goal of increasing the number of STEM majors at this institution.

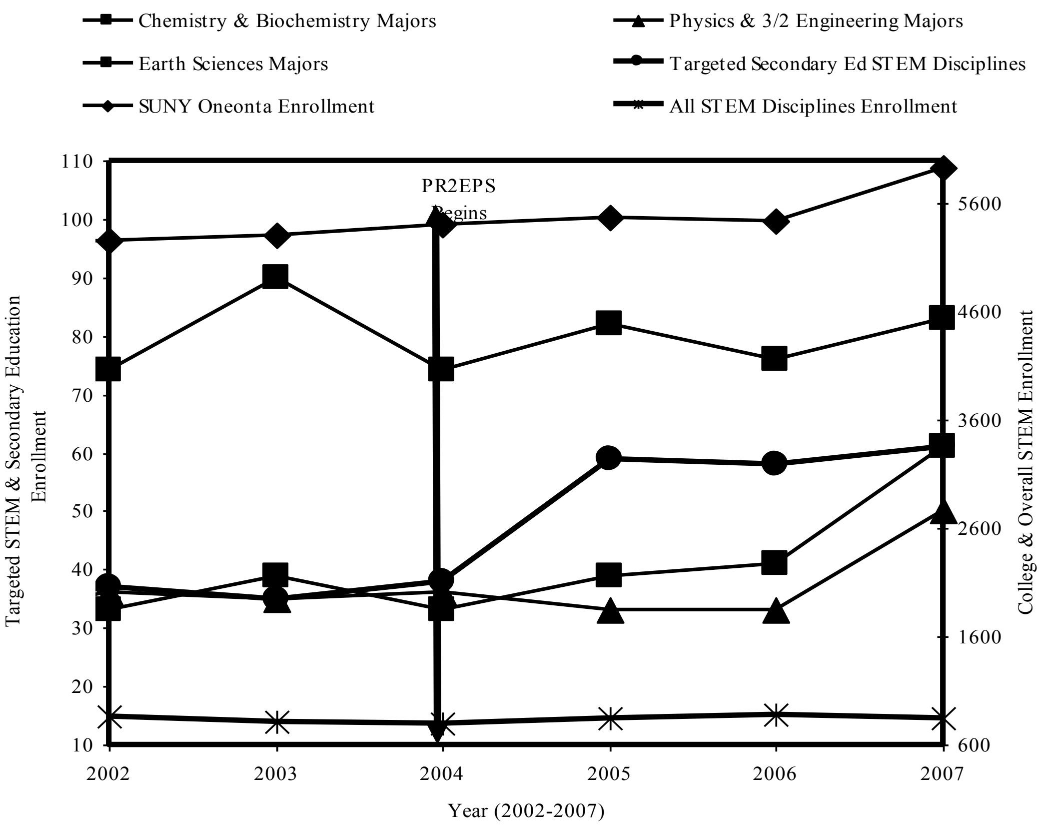

Figure 2. College enrollment data in targeted (Chemistry & Biochemistry, Physics and 3/2 Engineering and Science Education) programs. There are substantial increases in all there programs following PR^{2}EPS .

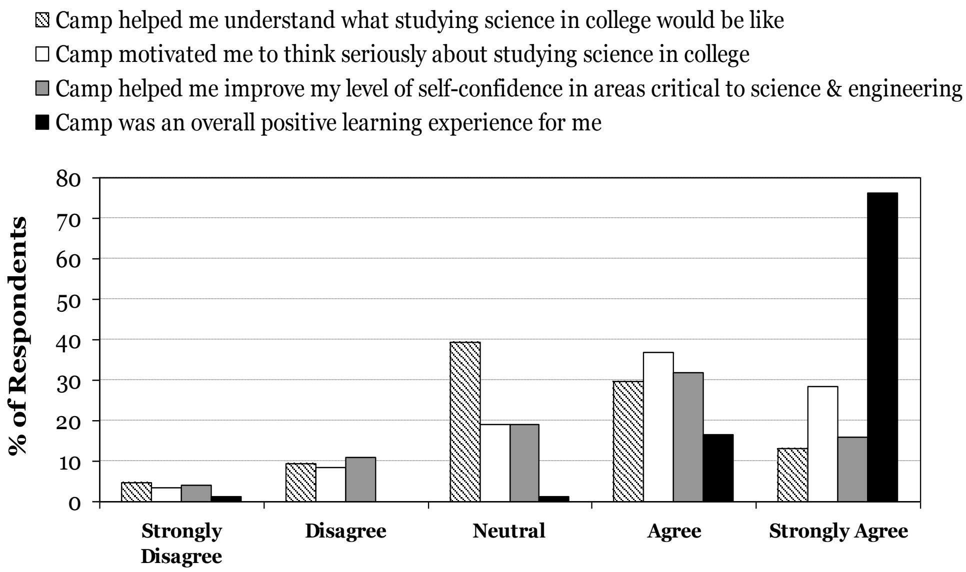

Figure 3. Data from the alumni survey.

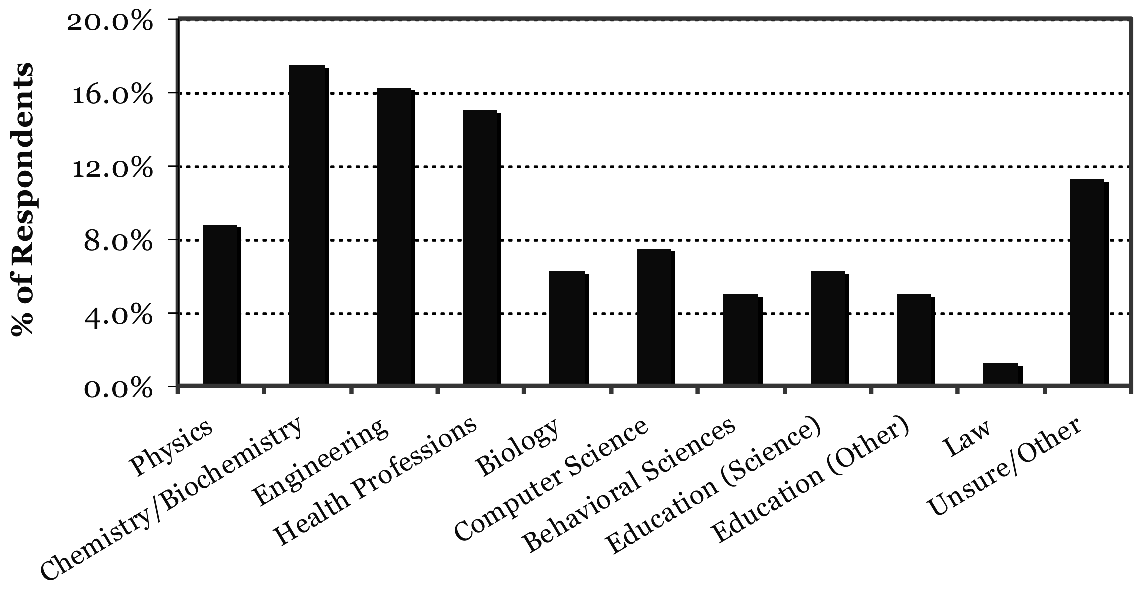

Figure 4. Data from the alumni survey (n = 84). Most respondents are currently or are planning on majoring in the physical sciences.

The data in Figures 3 and 4 were collected via our online alumni survey and were updated spring 2007. At that point, we had concluded three camps with 132 campers. Eighty-four or 64% or the camp alumni responded. We achieved this response rate by sending reminder post cards to non-respondents and ultimately calling the remaining students and asking them to visit the website and respond. We don't know if those who never responded differ systematically from the respondents.

The responses to all questions indicate that the camp was a positive learning experience, is improving self confidence in the sciences and is ultimately playing a role in what many are considering studying in college. The responses to all four selected questions in Figure 3 are supportive of the camp achieving its second goal of serving as a catalyst in motivating high school students to consider science as a major in college. For example, 70 out of 84 camp alumni responded with agree or strongly agree to the second item "the camp made me think seriously about studying science in college".

The data in Figure 4 supports the conclusion that the camp is achieving its goal of motivating students to attend college as physical science or science education majors. In total 59% of the respondents indicated their interest in chemistry/biochemistry, engineering, physics and science education.

Discussion

The numerical data presented demonstrate that the camp is meeting its primary objective of moving more high school students towards studying the physical sciences in college. Twenty-two percent of the camp alumni are currently attending this college. Fifteen other campers have applied for admissions. We do not know exactly how many are studying science at other institutions, but based on the response to the interest type questions on the alumni survey, several no doubt are.

The qualitative data reveal, at least in part, why the camp is so successful. The student voices speak strongly to the high quality of the camp experience. These campers are engaged in challenging scientific and engineering tasks that require teamwork, negotiation of meaning and application of scientific and engineering principles in an exciting and supportive environment. Because we have thus far been successful in achieving of our goal of providing a rich science and social environment that is motivating some to think seriously about majoring in the sciences and helping maintain others on their science career trajectory, for summer 2008 and beyond we are expanding the recruitment effort to encourage increased participation of campers from groups traditionally underrepresented in the sciences, particularly African American and Latino campers. Moreover, we are expanding the assessment piece to determine if and to what extent the experience as a camp counselor effects the pre-service science teachers' preparation.

Interestingly, at the end of the 2007 camp one of the main faculty said "this was the best camp ever!" Others laughed and responded with comments like "you said that last year and were right and you're right again." The point is our successes have been earned through high levels of collaboration, a commitment to excellence, and constantly learning from our mistakes, and recognizing our accomplishments. The model provided here may be very useful to other institutions interested in working towards motivating more students to major in the sciences.

Acknowledgements

The PR^{2}EPS program is funded by the National Science Foundation via awards DUE-0336580 and DUE-0441107. We would also like to express our sincere gratitude to the insightful comments of the external reviewers.

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