

Increasing the Participation of Under-represented Minority Student Groups in Computer Science and Engineering: An REU Site Experience

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Abstract - Statistics indicate that under-represented minority student groups continue to experience high dropout rates, low graduation rates, low enrollment in graduate programs and low participation in Computer Science and Engineering (CS&E). At the same time, trends indicate that these groups will constitute an important part of the population of the United States by year 2050. Given these facts, it is crucial to help these minority groups become an integral part of the economic fabric of the United States. It has been shown that undergraduate research is one of the best vehicles to address several of these important issues. This paper describes our experience running a NSF-sponsored Research Experiences for Undergraduates (REU) Site in CS&E for under-represented minority student groups. We describe the most important aspects that need to be included in these programs and some strategies for running them successfully. Finally, we include the results of our evaluation and show the effectiveness of the program.

Index Terms – REU, Computer Science and Engineering, undergraduate research, under-represented minority groups.

INTRODUCTION

Current statistics and trends in graduation, enrollment and participation of minority groups in Science and Engineering (S&E) are alarming. For example, according to NSF's Science and Engineering Indicators 2002, the enrollment in engineering has declined continuously from 1983 (441,000 students) to 1999 (361,000) by more than 20% [1]. Furthermore, the National Center for Educational Statistics (NCES) found in 2000 that, although 25-30% of students entering college intend to major in Science and Engineering, fewer than 50% completed their degrees within a 5-year period [2]. The study also notes that 20% of students dropped out of college and that the graduation rate of under-represented minority students is lower than that of other groups [3].

In recent reports [4,5], Hispanics are shown to be the fastest growing population in the United States and the largest minority group in the country. However, the report also indicates that Hispanics only account for 6, 4 and 3 percent of the bachelor's, master's and doctoral degrees, respectively, they are the least-

educated major ethnic group, and the group with the lowest graduate school enrollment.

There are several important reasons that contribute to making it difficult for Hispanic students to succeed in education. Among the most relevant of these issues is the increase in tuition rates, the lack of Hispanic professors (only 2.9% of full-time college faculty members), the lack of family models, inadequate student services, and poor lower-level education. If this important number of the total population of the country is to contribute to the nation's welfare and prosperity in the future, it is crucial for them to receive help now.

One recommended reform included in the NSF Science and Engineering Indicators 2002 report to meet the challenges of Science and Engineering (S&E) higher education is to increase the involvement of undergraduate students in research [1]. Motivated by these statistics and trends in graduation, enrollment and participation of minority groups in S&E, we submitted a REU Site proposal to the National Science Foundation in 2004 to provide students from under-represented minority groups the opportunity to be involved in a 10-week summer research program in Computer Science and Engineering (CS&E). The proposal was funded by NSF for three years and we just completed the first summer program.

This paper describes our program and its unique characteristics in the next section. The next section lists the program's objectives followed by the most important aspects that we consider all REU programs must have to be successful. The strategies that provided the best results in our case are also described. Then, we include the results of our program evaluation, and finally, the last section concludes the paper.

GENERAL PROGRAM DESCRIPTION

The title of our REU Site is "A Computer Science and Engineering REU Site for Florida, Puerto Rico and Latin America". Compared to other REU Sites, ours is unique in mainly two aspects. First, it is not devoted to a particular theme or topic. Instead, it is fairly open, giving students a broad range of research project options in Computer Science and Engineering. For example, we included research projects in robotics, computer networks, transportation, computer architecture, data mining, artificial intelligence, and digital image processing. The second unique aspect is that, based on the statistics presented above, we

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committed to recruit the majority of the students from the Hispanic minority group, mainly from Florida and Puerto Rico. In addition, we also committed ourselves to bringing at least one student from a Latin American country each year.

Most of the other aspects of the program are fairly standard. The program was run for 10 weeks during the summer semester, in our case from May 31 to August 5, 2005. We provided each student with a stipend, travel and housing support, and an allowance for meals. During the 10-week period, students were assigned to faculty mentors from various departments and research centers in the College of Engineering to work on the research projects of their choice. In addition, several workshops, presentations and social activities were included in the program. All of this information is available on our Web site at <http://www.csee.usf.edu/REU/>.

PROGRAM OBJECTIVES

The program seeks to achieve the following objectives:

1. **Increase student involvement from under-represented populations.** Our primary goal is to involve minorities as much as possible with an emphasis on the Hispanic group.
2. **Better prepare undergraduates for their professional careers.** We expect the students to learn how to use state-of-the-art tools and methods to solve current research and practical problems. We also want them to improve their written and oral communication skills through seminars and formal and informal presentations about their projects.
3. **Increase recruitment of students in graduate programs.** This REU program is meant to enhance the students' curricular activities to keep them more engaged in their field of study and thus increase graduation rates. Students will be able to work side-by-side with faculty members on interesting and challenging technical problems and realize the importance of graduate education in meeting these challenges. They will also attend presentations describing the advantages of graduate education, the application and admissions process, and available funding opportunities.
4. **Improve student capability for learning independently.** Faculty mentors will provide the students with in-depth information and guidance at the beginning of their research assignments. After that initial phase and once given all the tools they need, we expect and encourage students to work and learn independently.

Our program also seeks to foster the internal REU program at our College of Engineering [6,7], help faculty mentors in their research endeavors, and build stronger ties with minority institutions by helping their students achieve the stated objectives.

COMPONENTS OF A SUCCESSFUL REU PROGRAM

Although it seems a simple endeavor, running a program like this one requires more time, preparation and organization than we originally estimated. A successful program requires careful design and implementation of all of its components. Core components which are critical to the success of the program are described in the following subsections, including several

implementation possibilities and the ones that provided the best results for our program.

I. Recruitment Plan

Recruitment is perhaps the most important program component. A good recruitment plan is necessary in order to guarantee that the program will benefit those for whom it was developed. Recruitment during the first year of a program is especially difficult, since there is not much time between the time the grant is awarded (in our case at the end of January) and the beginning of the 10-week summer program.

We utilized most recruitment strategies currently in use. The first strategy is to set up a website and advertise it. Advertising the website address can be done in a number of ways. For instance, we designed a flier that we put on all bulletin boards around the College of Engineering. We advertised the program in many of our undergraduate classes and in meetings of technical societies. We sent e-mails and letters (with the flier attached) to all computer science department chairs and many other faculty members that we knew in Florida. The National Science Foundation included our program's URL in the list of NSF-funded REU Sites [8]. In addition to advertising our website we also visited the University of Puerto Rico-Mayaguez and held a student recruitment presentation there, including an afternoon-long session to answer questions on an individual basis. We also advertised our program with local minority societies and utilized links already in place with other minority organizations, such as the Florida Georgia Louis Stokes Alliance (FGLSAMP) [9] and the College's Office of Recruitment and Retention.

Our recruitment efforts yielded a total of 42 applications. We received 9 applications from Puerto Rico, 4 from Latin America and Spain, 13 from Florida, and 16 from outside of Florida. We can say that personal contact and the NSF Web site were the most successful recruitment tools.

Students were selected on the basis of demographic information, GPA, courses and skills related to the research projects that they chosen to work on, career objectives, letters of recommendation and project selection. We finally brought in six Hispanic students from the University of Puerto Rico-Mayaguez, two Hispanic students from our own College of Engineering, two African-American students (one from Bethune Cookman and one from Florida A&M), two students from the Universidad del Norte in Barranquilla, Colombia, and one student from Universidad de Navarra in Spain, for a total of 13 students. It is important to mention that the NSF grant only supported 9 students. One student was supported by FGLSAMP; the students from Colombia were supported by our College and the Universidad del Norte; the student from Spain was self-supporting.

II. Program Evaluation

Program evaluation is another component that should be included in all REU programs. It is necessary to know if the program's objectives are being met. Evaluation is also needed to identify areas of the program that require improvement. Program evaluation can be done either by the PIs or by an entity specialized in program evaluation. We chose the latter option because it offered a more efficient methodology for collecting and

TABLE I
A PROGRAM EVALUATION GUIDE

Objective	Primary questions	Data source	Time frame
Assessment of program awareness and recruitment.	How effective are the methods used to advertise the REU program? How successful are recruitment methods in securing diverse students?	Review of recruitment material and procedures; Review of applications received; Demographic data.	Prior to program.
Assessment of expectations.	What are the faculty members' and students' expectations? Were they met? How well the program was organized and delivered?	Survey administered to faculty and students at the beginning and conclusion of the program.	Before and after program to faculty and students.
Assessment of program's objectives.	Did we increase minority participation? Did the program provide the students with skills and knowledge that they felt could be effectively used in their careers? Have we improved the students' capability to learn independently?	Collect information about diversity (topics, cultures, places), communication skills, feelings about engineering, preparation (tools, techniques, methods), ability to continue learning and doing research independently.	Before, during and after program to students.
Assessment of long-term effects.	Is there evidence that the program has had an impact on students' interests? Did we increase the enrollment in graduate programs?	Is there evidence that the program has had an impact on students' interests? Did we increase the enrollment in graduate programs?	Follow-up survey 6-8 months after program to students.

analyzing data and it ensured unbiased results. We utilized specialists from the USF Center for Research, Evaluation, Assessment and Measurement (CREAM) [10].

It is important to collect information before, during, and after the program. A survey instrument was designed for each of these time intervals. The first survey mainly collected demographic information and student expectations. Other types of questions were asked to find out about the application process, factors that influenced their decision to join the program, how they found out about the program, etc. During the program, we conducted a weekly evaluation to identify trends in important aspects of the program as well as to detect problems as they occurred. This part of the evaluation was rather short and was implemented in a user-friendly Web application. Students were asked about their day-to-day experiences, professional development and general thoughts about the REU experience on a weekly basis. The third survey collected information used to evaluate the entire program to determine if the objectives were achieved and if the student expectations were actually met. For example, we asked questions regarding satisfaction with facilities, services, and management, usefulness of the workshops and presentations. This survey also included open-ended questions regarding positive and negative aspects of the program. The final survey will be sent twelve months after the end of the summer program. In this last survey we want to collect information about the long-term impact on the students' lives and careers.

Table I is a sample program evaluation guide. It shows the evaluation objectives, the type of questions that need to be answered, the type of data that needs to be collected, and when this data collection process needs to take place.

III. Projects and Professors

The second most important component is finding faculty mentors and interesting research projects. This needs to be done at the very beginning so the projects can be advertised. Projects need to be geared to juniors or seniors and designed so that goals can be achieved in a ten-week period. Depending on the number of

students, it might be difficult to find the appropriate number of faculty members available during the summer months. Students need a lot of time and attention from their faculty mentors, especially during the first half of the program. A recommended strategy is to have additional projects and faculty mentors available in case some faculty member cannot work over the summer with these students or students want to change their research projects. This strategy proved to be very useful in our case, as one faculty member had to fly to his home country due to a family emergency and two students wanted to pursue different projects after the first week.

This summer students worked on ten different projects either individually or in groups of two. They participated in weekly research meetings with other faculty, students and researchers. More information about the faculty mentors and the projects can be found on the program's web page.

IV. Social and Educational Components

A number of social and educational activities need to be scheduled. Social activities may vary from REU Site to REU Site depending on the city in which the program is located and the facilities available nearby. An important factor to consider when planning these activities is that students come from different geographical locations and usually do not have their own transportation. Even though our students had restaurants, movie theaters, a shopping center, and a recreational park within walking distance or a short bus ride, we also arranged several other social activities for them.

Educational and other informational presentations were also arranged. We organized workshops on library research techniques, ethics, poster design, presentation skills, writing research papers, getting into graduate school, financial opportunities, patents and licensing, nanotechnology, and strategies for success in professional careers. Several of these presentations were organized as lunch seminars. In addition, we scheduled two presentations where students highlighted their accomplishments at the middle and the end of the ten-week

TABLE II
THIRD PART OF THE WEEKLY SURVEY

General thoughts about the REU experience so far	Not at all	Somewhat	Definitely
I am enjoying this experience overall.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe this experience is adding to my engineering skill set.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am getting ideas for other research initiatives.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This experience will enhance my ability to be successful in finishing my degree.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
This experience will provide me with confidence to pursue other research experiences next year.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would do this again if given the opportunity.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would recommend this program to my peers.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

period. We also held a formal poster competition where small cash prizes were awarded. Since there were other REU programs running at our university this summer, some of these social and educational activities were shared with these other programs and the students from all REU programs were housed together.

V. Administration Time

There are a large number of administrative tasks required to run an REU program such as this one. The organization of the workshops, caterings, poster competition, social activities, payroll and reimbursements, housing arrangements, recruitment activities, program evaluation, use of university facilities and services, receiving and registering applications, selecting the students and sending official acceptance and rejection letters, etc., are only some of the tasks that we recall now. The fact that some of the students were foreign students required extra time and effort on our part as PIs. In addition to obtaining a visa, these students needed help to obtain health insurance, open bank accounts, and obtain social security numbers. Finally, there are always questions about the projects and technical meetings (we, the PIs, were mentors as well), and behavioral problems to deal with. In our case, we definitely underestimated the amount of time needed. However, this wonderful group of students that we worked with made the entire effort worthwhile. The best strategy is to start early and make a weekly plan of activities.

PROGRAM EVALUATION

As mentioned above, the goal of the evaluation effort is to gather evidence about the impact of the program and assess the degree to which it is meeting its stated objectives. From an evaluation perspective, there were three main areas that the evaluation team focused on. These three areas contain both formative and summative aspects of evaluation to help guide the remaining two years of our program. The evaluation was designed to identify elements of the REU program that 1) are positive or problematic logistically; 2) enhance and/or add to current knowledge; and 3) were positive or negative aspects of the program delivery.

I. Evaluation Data

As mentioned previously, the program evaluation includes 4 data collection efforts. One pre-survey, one weekly survey, one survey at the end of the program, and a final questionnaire that will be delivered twelve months after this year's program.

A. Pre-Survey

The pre-survey was administered the very first day of the program. Students were asked questions regarding previous experiences, recruitment, and program expectations. They all stated that the application procedures were clear. Most of the students said "no" in response to the question, "Is there information or personal contacts that you did not receive but would have found beneficial in planning and preparing for your Summer REU experience?". One student wanted a schedule and another expressed concerns about the clarity of the living accommodation descriptions. Various responses were given regarding factors influencing the decision to participate in the program and the impact of the stipend on the decision. To the question, "What do you anticipate getting out of this program?" responses varied with an emphasis on growth in research skills and knowledge in Computer Science. Some mentioned enhancing communication skills.

B. Weekly Survey

The weekly survey consisted of 24 items; twenty-three items used a Likert scale consisting of three response options (Not at all, Somewhat and Definitely). The 24th item was an open-ended item giving students a chance to provide comments, suggestions or any information they thought might benefit the program.

The survey was divided into three sub-sections. The first section consisted of nine items asking students to comment on their general experiences that week. Items within this section asked students about their comfort in asking for assistance and their work environment, whether they knew what was expected of them, and whether the level of guidance they had received was adequate for their assignments. The Chronbach's alpha for these items was 0.88.

Section two contained five items asking students about their professional development for that week. Students were asked if the week's experiences added to their knowledge in their field, helped them grow as an engineer, and if those experiences increased their enthusiasm for becoming an engineer. The Chronbach's alpha for these items was 0.92.

The third section consisted of seven items and asked students about their general thoughts about the REU experience to date. Items in this section asked whether they would recommend this program to their peers, would they participate in the program again if given the chance, whether this experience would provide them with confidence to pursue other research experiences in the next school year and did they believe the experience was adding to their engineering skill set. Two additional items were added to

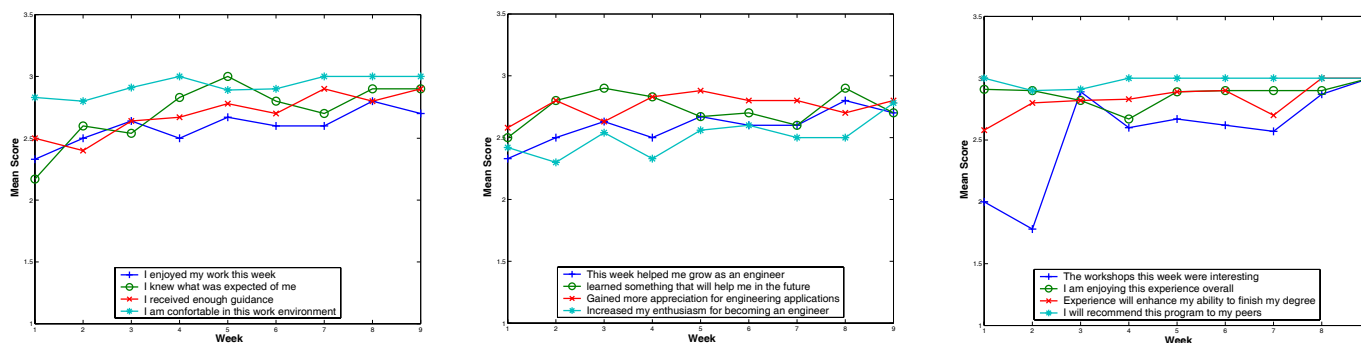


FIGURE 1
WEEKLY SURVEY: PART ONE MAIN RESULTS (LEFT), PART TWO (CENTER), PART THREE (RIGHT).

this section asking about workshops, to be answered only if workshops were offered that particular week. The items asked if the workshops were interesting and did they provide useful information. The Chronbach's alpha for these five items was 0.75, which suggests an adequate level of reliability. As an example, in Table II we show the third part of our weekly survey.

Figure 1 presents the main results of the weekly survey. The scale ranges from one (Not at all) to three (Definitely). Figure 1 (left) shows the most important results from part one survey (general experiences). Overall, the curves display a positive increase across time and suggest that students generally view their general experiences for the week as positive. For example, from the responses to the question "I knew what was expected of me this week" week one shows a mean of 2.17, which steadily increases through week five where it reaches a value of three and dips down by week seven to a mean of 2.7 and back up to a mean of 2.9 by week ten. These values imply that the majority of students were indicating the "Definitely" response to this item after week four. Responses to the questions, "I received enough guidance this week to do what I need to do" and "I enjoyed my work this week", show an overall positive climb across weeks. The figure also shows that nearly all students felt really comfortable in the work environment during the program.

Figure 1 (center) presents some of the results of the second part (professional development). To the question, "This week helped me to grow as an engineer", a positive increase over the ten-week period can be seen. When students were asked, "My experiences this week have increased my enthusiasm for becoming an engineer", they reported starting out at 2.4 and again a positive increase is seen throughout the remainder of the program. Responses to the question, "Learned something that will help me in the future", show that the students acquired a lot of knowledge during the first two or three weeks and then they just applied what they learned in the rest of the program. Finally, to the question, "Gained more appreciation for engineering applications", students seemed to have gained much appreciation during the first weeks and then continued appreciating engineering applications equally.

Results for the third part (general thoughts about the program) are shown in Figure 1 (right). Responses to the question, "I am enjoying this experience overall", start out high with means of 2.9 and drop to 2.67 at week four, and then rise to 2.9 and then 3.0 the last week. This suggests that the students

viewed their experience as positive throughout the ten-week period. When asked if "I would recommend this program to my peers" (and also "I would do this again if given the opportunity" - not shown in the figure) the students were almost unanimous in their response of "Definitely". This certainly suggests that they found this a worthwhile endeavor. The figure also shows that the students found the library research workshops not very useful. On the other hand, they found the workshops on poster presentation and presentation skills given during the third week very useful. They also found the nanotechnology workshop, the final presentations and the poster competition very useful. The rest of the workshops received a fair rating.

C. End-of-Program Survey

The post-survey was administered at the end of the program. The items addressed the REU and overall University of South Florida experience, satisfaction, and expectations. All of the students said they enjoyed the REU experience. Ninety-one percent indicated they definitely agreed that the experience was at an appropriate level of skills, knowledge and ability. 91% of the students also responded that they definitely agreed that the faculty was available for assistance. The students responded to the statement, "I knew what was expected of me during the REU program", with 64% choosing "Definitely" and 36% choosing "Somewhat". The items, "I had enough information to do what I needed to do" and "My project was appropriate for the program length", received similar responses with 64% stating "Definitely", 27% stating "Somewhat", and 9% stating "Not at all".

Personal development items were addressed by the post-survey with the majority of the students expressing strong support. The item, the REU program facilitated their professional growth in engineering and helped them appreciate and understand what is involved with being a graduate student, received strong support from 91% of the students. The items about the program increasing enthusiasm for becoming engineers and enhancing interest in pursuing other research projects had 72% in strong agreement, 18% somewhat agreeing, and 9% disagreeing.

Students were asked to report on various elements of the REU program. Weekly meetings with other students were found very useful by 73% of the students. Weekly workshops were rated as very useful by 36% and 55% somewhat useful.

The comprehensive university experience was addressed as well. All students were very satisfied with lab access. 82%

percent expressed satisfaction with the dormitory, meal services, travel arrangements and library access. Satisfaction ratings for recreational activities, assistance with making arrangements for attending these activities, and assistance from REU management in resolving issues received “very satisfied” from 73% of the students. 64% of the students were “very satisfied” with the information received before arrival, 27% were “somewhat satisfied”, and one student chose the “not satisfied” option. The students’ responses to the university services item varied with 45% being “very satisfied”, 27% “somewhat satisfied”, 18% “not satisfied”, and one choosing the “not applicable” option.

Finally, the post-survey found that 91% of the students would definitely recommend the program to their peers and are more interested in pursuing an advanced degree.

II. Evaluation Results

Based on the evaluation results just described, the following conclusions can be drawn about the degree to which the stated objectives of the project were met.

The program’s objective of increasing the involvement of students from minority groups was achieved fully this first year since all students participating were from traditionally under-represented groups. We also increased the number of students in the program utilizing non-NSF funding sources.

The evaluation results also appear to strongly support the students’ perceptions that the program is providing them with additional skills and experiences that will enhance their ability to be successful in the engineering profession. Additionally, all respondents to the student post-survey indicated that they felt that the experience in the REU program promoted their professional growth. Therefore, it appears that objective 2, better preparing undergraduates for their professional careers, was achieved.

Survey data from the first year of the program does not directly measure the ability of the program to increase recruitment of students in graduate programs (objective #3). However, most students indicated in the post-survey that their experience had increased their interest in pursuing an advanced degree.

Participation in the program appears to have positively influenced students in regards to pursuing other research projects as well as advanced training and education. Additionally, the weekly survey shows a marked increase in such areas as their comfort level with expectations as well as their ability to do what was expected of them. Taken together with some of the other data, these indicators suggest to us that students increased their comfort level and enthusiasm for engineering and their capability for learning independently (objective #4).

Evaluation results regarding the program administration were primarily positive with few exceptions. Students seemed satisfied with logistic arrangements with some concerns about availability of some university facilities such as the main fitness center. One student noted that he thought telephones and televisions were provided in the dorm rooms since preliminary information indicated that these services were included.

As to the identification of program elements that enhance or add to current knowledge, the majority of the responses were positive. However, survey results indicated that some of the workshops were not found to be especially helpful. This was the

only component of our REU summer program that did not receive a strong positive response from the students.

Most students rated the organizational aspects of the program in a highly favorably manner. A few areas were identified as needing improvement such as the workshop topics, including more information prior to arriving on campus, and organizing more field trips to industries. Additionally, some students suggested more advertisement of the program.

After evaluating this first year of our REU program we will take the following actions before starting next year’s program: 1) review and revise workshop topics; 2) before arriving, send the students an in-depth description of the program and what is expected of them and include more detailed information about university services and living accommodations; 3) improve advertising methods; and 4) track first-year students gathering data about their career or education choices after graduation.

CONCLUSIONS

Research Experiences for Undergraduates (REU) programs are an effective vehicle for involving under-represented undergraduate minority students in university research activities with the ultimate goal of ameliorating the trend of under-representation of minority students in Science and Engineering. However, these programs must be designed and implemented carefully so that they achieve their objectives. This paper describes the most important components of this type of programs and our experience running one for the first time.

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REFERENCES

- [1] Science and Engineering Indicators 2002. National Science Board, <http://www.nsf.gov/sbe/srs/seind02/start.htm>, 2002.
- [2] Entry and Persistence of Women and Minorities in College Science and Engineering Education. U.S. Department of Education, National Center for Education Statistics (NCES), <http://www.nces.ed.gov/pubsearch/>, 2000.
- [3] Science and Engineering Indicators 2002. Higher Education in Science and Engineering. National Science Board, <http://www.nsf.gov/sbe/srs/seind02/>.
- [4] Status and Trends in the Education of Hispanics. U.S. Department of Education, National Center for Education Statistics (NCES), <http://nces.ed.gov/pubs2003/2003008.pdf>, April 2003.
- [5] Educating the Largest Minority Group. Hispanics and Higher Education. The Chronicle of Higher Education, November 18, 2003.
- [6] USF College of Engineering Research Experience for Undergraduates (REU) Program. <http://www.eng.usf.edu/~schlaf/REU/>.
- [7] M. A. Labrador, J. Wolan, G. Centeno, A. Kumar, G. Mullins, and R. Schlaf. A Research Initiative to Close the Gap between Undergraduate and Graduate School in Engineering. In *Frontiers in Education*, S1B-1-5, 2004.
- [8] National Science Foundation REU Sites. <http://www.nsf.gov/crssprgm/reu/>
- [9] The Florida Georgia Louis Stokes Alliance for Minority Participation in Science, Engineering and Mathematics. <http://www.fglisamp.com/>.
- [10] USF Center for Research, Evaluation, Assessment and Measurement (CREAM). <http://www.coedu.usf.edu/cream/home.htm>.