Access to Engineering:
A Description and an Evaluation of a Pre-Collegiate Program for Minorities and Women

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The University of Missouri-St. Louis/Washington University Joint Undergraduate Engineering Program

Background

In 1990, the Congressional Research Service presented a major report to congress on the status of underrepresented minorities and women in science, mathematics, and engineering.[10] In that report, Matthews (p. 65) stated that:

> The discrepancy between minority participation in science, mathematics and engineering and overall minority trends is one of the most critical issues confronting the educational system.

For example, by the year 2000, 85 percent of those entering the labor force for the first time are expected to be women, minorities, immigrants, and disabled individuals. Furthermore, in 1990, 23 of the largest 25 school districts in the United States were dominated by "minorities." Accordingly, the need to diversify the pipeline of engineering students arises not only from a desire to provide equal opportunity to all, but from a very practical concern of a serious shortfall of scientists and engineers in the very near future.[1]

Many reasons have been cited for the low enrollments and poor retention of women and minorities in mathematics, science and engineering. Reasons include the absence of role models,[7,22] a shortage of minority faculty and administrators in universities,[21] lack of encouragement to women and minorities to continue in programs,[14] financial difficulties,[11] cultural stereotypes concerning women and minorities,[5,13,16] and outright discrimination.[6,8]

However, an immediate stumbling block for women and minorities to program admission and success at the college level appears to be the inadequate preparation in mathematics and science in high school.[19] For example, students who take more science courses in high school have higher standardized test scores and do better in freshman science courses.[2] Female and minority students are less likely to participate in science and mathematics enrichment programs and often end up in high school "tracks" that provide little mathematics or science.[6]

Furthermore, students selected for advanced study in mathematics and science at the secondary level are usually the "cream," and therefore are a very small group. A different model has been proposed that argues for broadening the pool of potential students at the secondary level, rather than "skimming the cream."[23] Others have also argued that there is a larger, able, potential pool of students below the very top group that should be encouraged to pursue careers in mathematics, science and engineering.[4,15] Many of these students are women and minorities.

In response to the need to recruit minorities and women to mathematics, science and engineering at the college level, special pre-collegiate programs were initiated in the mid-1970s, and have proliferated.[10,12] These programs have received substantial support from the federal government, notably the National Science Foundation, the National Aeronautics and Space Administration, the Department of Defense, and the Environmental Protection Agency. At the state level, California and Iowa have been very actively involved in promoting such programs. Several universities, such as Syracuse University, Howard University, Xavier University, the New Jersey Institute of Technology, University of California at Berkeley, the New Mexico Institute for Mining and Technology, and the State University of New York have promoted a variety of programs. Private foundations, corporations and professional societies have contributed extensively to the development of pre-collegiate programs for women and minorities.

Few programs that have been operating for any significant period of time have been systematically evaluated[10,20] although results look promising. Some characteristics of programs that appear to be successful have been identified, such as clearly articulated goals and objectives, specific intervention strategies, teachers who are competent and have high expectations for students, role models from the targeted minority population group, and parent involvement.[12] Furthermore, successful program strategies seem to involve an integrated approach to mathematics and science, peer support systems, encouraging students to work in teams, a focus on higher level cognitive skills, practical applications of mathematics and science, enrichment activities that emphasize the scientific process, “hands-on” laboratory activities, and a focus on real-life problems.[12] In addition, there seems to be some agreement that remedial programs do not appear to be as successful as enrichment programs.[9]

A new partnership of the University of Missouri-St. Louis and Washington University, the Joint Undergraduate Engineering Program,[18] is helping companies meet the goal of creating a workforce that is diverse in terms of both ethnicity and gender. The goal of the Joint Program is to make an undergraduate engineering education available to place-bound students in the St. Louis area by combining the strengths and resources of the UM-St. Louis and Washington University. The program now offers Bachelor of Science degrees in Civil, Mechanical, and Electrical Engineering, as well as a Minor in Environmental Engineering Science, to a previously under-served population. The target group of students includes a much larger than average representation of women and minorities.

A natural outreach activity of the Joint Program is the McDonnell Douglas Access to Engineering Program. The primary purpose of the program is to recruit talented minorities (especially African-Americans) and women to the field of engineering. Access to Engineering combines the strengths of two urban institutions of higher education, one public and one private, to provide unique experiences and opportunities for these student populations with the goal of both recruitment and retention in engineering. A major component of the Access to Engineering Program was the pre-collegiate institute for high school juniors and seniors, held during the summer of 1995. This was an intensive, eight-week, all-day program in mathematics and engineering for promising high school students with backgrounds that are under-represented in the field of engineering.

Overview of the Program

One goal of this program was to address the critical need for the enhancement of mathematics skills necessary to ensure a smooth transition from high school mathematics to the rigorous mathematics requirements of a pre-engineering curriculum. Often, the nature of the transition from high school algebra and trigonometry to college calculus determines whether a student will pursue a degree in engineering. Our objective was to ensure that mathematics would not become a barrier. As a result, the students spent each morning taking either a specially developed precalculus course or a college calculus course depending on how they scored on a mathematics proficiency examination. It should be noted that the calculus course was a regular UM-St. Louis section of calculus I, and the Access students received college credit.

Although the mathematics instruction was a very important and necessary part of the program, another equally important goal was to introduce the students to the field of engineering and the challenges of an engineering career. Nearly all high school students have taken courses in mathematics and the natural sciences; however, very few, if any, have had any experience with engineering. Toward this end, the afternoon sessions of the Access Program were devoted to providing the participants with both hands-on engineering activities and exposure to the engineering disciplines of civil, electrical and mechanical engineering.

The major goal of the introductory engineering experiences was to enable the participants in the program to understand engineering as both a career and a major. As a result, participants were provided both a hands-on introduction to engineering and exposure to the kinds of challenges that engineers face as working professionals. The three major elements of the introductory engineering experience were field trips, engineering laboratories at Washington University, and lectures on various topics by engineers and other professionals. These activities were further organized to emphasize the role of mathematics and science in engineering, engineering in society, and the three degree offerings available in the joint program; namely, civil, electrical and mechanical engineering.

All students who participated in the Summer Institute received a stipend of $100 per week. This was provided to offset lost income from possible summer employment since the program was intensive and required a principal time commitment from the participants. In addition, all students who successfully completed the program (measured by receiving a grade of C or better in the mathematics courses) received a full tuition scholarship for their first year of study in pre-engineering at UM-St. Louis. This was provided as an incentive to complete the Summer Institute and to offset another potential major barrier to success; namely, limited resources to pay for a college education.[3,10,11]

Recruitment to the Program

Recruitment for the program began in February 1995 by sending out packets of information announcing the program and requesting nominations from mathematics and science teachers, guidance counselors, and principals in area high schools. A total of 744 packets were mailed to 105 metropolitan area high schools, both public and private.

A total of 194 students were nominated, of which 78 percent were under-represented minorities and women. A detailed breakdown of the nominees' ethnic backgrounds and gender is provided in Table 1, below.

Table 1. Ethnic Background and Gender of Nominees

	Male	% Total	Female	% Total	Unknown	% Total	Total	% Total
African-American	33	17%	46	24%	0	0%	79	41%
Asian-American	11	6%	6	3%	0	0%	17	9%
Hispanic	0	0%	3	2%	0	0%	3	2%
Caucasian	42	22%	39	20%	0	0%	81	42%
Unknown	8	4%	3	2%	3	2%	14	7%
Total	94	48%	97	50%	3	2%	194	100%

Selection criteria were developed and used to determine which of the nominees would be invited to take the UM-St. Louis mathematics placement examination with the intent that the test scores would be used to determine full acceptance into the program. The selection criteria were: (a) minorities and women, especially African-Americans; (b) interest in an engineering career; (c) grades in high school mathematics courses; (d) standardized test scores; and (e) potential interest in the Joint Undergraduate Engineering Program. A less tangible quality, "promise," was also considered. Thus, not all of the students were necessarily at the very top of their classes.

Of the 194 nominees, a total of 49 students were provided conditional acceptance and invited to take the mathematics placement exam. A breakdown of the student's ethnic background and gender who were included in this group is provided in Table 2, below. Asian-American students were included because they are a distinct minority group on the UM-St. Louis campus, even though they are not underrepresented nationally.[10]

Table 2. Ethnic Background and Gender of Selected Nominees

	Male	% Total	Female	% Total	Total	% Total
African-American	14	29%	11	22%	25	51%
Asian-American	4	8%	1	2%	5	10%
Hispanic	0	0%	2	4%	2	4%
Caucasian	0	0%	17	35%	17	35%
Unknown	0	0%	0	0%	0	0%
Total	18	37%	31	63%	49	100%

As indicated above, the mathematics placement exam was used to determine the level of mathematics preparation; a score which placed the students at a level of readiness for college algebra or above was required for full acceptance into the institute.

A total of 44 students took the placement exam and 37 were granted full acceptance into the program based on their mathematics placement scores. It should be noted that some students did not place high enough the first time they took the placement exam but were given the opportunity to attend a two-session workshop and then retake the exam. A breakdown of the ethnic background and gender of the 37 students admitted to the institute, and how they scored on the mathematics placement exam is shown in Table 3.

Table 3. Gender and Ethnicity by Level of Performance on the Mathematics Placement Exam

	Precalculus	% Total	Calculus I	% Total	Total	% Total
African-American males	9	24%	4	11%	13	35%
African-American females	4	11%	1	3%	5	14%
Asian-American males	2	5%	2	5%	4	11%
Asian-American females	1	3%	0	0%	1	3%
Caucasian females	9	24%	5	14%	14	38%
Total	25	68%	12	32%	37	100%

A comparison of Tables 2 and 3 shows that most students who took the mathematics placement exam scored at least at the precalculus level. Ninety-three percent of African-American males (13 of 14), all Asian-American males and females (4 of 4 and 1 of 1, respectively), 82% of Caucasian females (14 of 17), and 45% of African-American females (5 of 11) received a satisfactory score. However, the comparison also reveals a tendency for females to score lower than males. This finding is consistent with other research that has shown the lower performance of females in mathematics by the time they reach college.[17] African-American students have also been found to score lower on standardized tests of quantitative ability, such as the SAT.[6] Although the selected African-American males did very well, the effect of ethnicity can be observed between the Caucasian females and the African-American females. The effects of both ethnicity and gender were particularly pronounced for African-American females.

Description of the Program

All students accepted to the institute and their families were invited to attend an open house that was held on Saturday morning, June 3, 1995. At this time, the students and their families were introduced to the institute's staff and were provided with an overview of the Access to Engineering Summer Institute's schedule describing the activities planned for the eight-week summer session. A presentation describing the UM-St. Louis/Washington University Joint Undergraduate Engineering Program was also provided.

The summer institute began on Monday, June 12, 1995, with all students attending an initial morning orientation meeting. As indicated previously, the students attended a mathematics class every morning. A total of 25 students attended the precalculus class from 8:30 to 10:30 AM. The remaining 12 students attended the calculus I course from 7:45 to 9:45 AM. Mathematics study sessions were held each day from 10:30 AM to 12:30 PM. Two sections were provided for the precalculus students and one for the calculus I students. The calculus I students only had class Monday through Thursday mornings and attendance at a Friday morning study session was optional. Each study section had a mathematics tutor available to provide help to the students as required. In addition, the tutors graded the homework that was assigned to the students the previous day. Finally, these study sections were also used to complete and collect daily activity evaluations from the students, and to communicate any important announcements from the institute's staff.

Lunch was provided for the students daily from 12:30 to 1:30 PM. The students then assembled for the afternoon pre-engineering activity. As indicated above, these afternoon activities consisted of field trips, engineering laboratories, and lectures on various topics. The amount of time devoted to specific topics is shown in Table 4 below.

Table 4. Afternoon Activities by Topic and Time Devoted

Afternoon Topic	Weeks
Role of Mathematics and Science	1
Electrical Engineering	2
Civil Engineering	2
Mechanical Engineering	2
Engineering in Society	1

As indicated, the first week attempted to demonstrate clearly to the students the role of mathematics and science in engineering. In addition, a session on group dynamics and team building was provided since most of the subsequent afternoon laboratory and work sessions were completed by students working in groups. The week ended with a field trip to Six Flags Over Mid-America where the staff and students used basic algebra/trigonometry and physics principles to make specific measurements concerning the dynamics of popular rides at the amusement park which included their height, speed and various gravitational forces experienced by passengers.

The remaining afternoon sessions are summarized in the following tables by the categories of field trips, labs, and presentations. First, Table 5 provides a list of the field trips taken by order of engineering major and the discipline within that major.

Table 5. Field Trips by Major and Discipline

Field Trip	Major - Discipline
Six Flags	Mathematics and Science
Science Center	Science and Engineering
Downtown Stadium	Civil - Construction Site
Lock and Dam 26	Civil - Flood Control and Barge Transportation
Landfill	Civil - Environmental
MetroLink	Civil - Transportation
Union Electric Headquarters	Electrical - Computer Control
Union Electric Power Plant	Electrical - Power Generation and Distribution
Siemens Manufacturing	Electrical - Electronic Assembly
Museum of Transportation	Mechanical - Transportation
McDonnell Douglas Prologue Room	Mechanical - Aerospace
Walgreens Distribution Center	Mechanical - Automated Control System

Next, Table 6 provides a summary of the laboratory sessions held at Washington University. In the AutoCAD laboratory, each student worked individually at a workstation and was introduced to automated drafting and design techniques. In the other laboratories, the students worked in groups of three, and were typically required to learn basic construction techniques and to use the instruments in the laboratory to make specific measurements.

Table 6. Laboratory Topics by Major

Laboratory	Major
Computer Aided Design (AutoCAD)	Civil
Concrete Construction	Civil
Concrete Destruction	Civil
Environmental Monitoring	Civil
Hands on With Structures	Civil
Three-way Switch	Electrical
Light Emitting Diode (LED) Sequencer	Electrical
Regulated DC Power Supply	Electrical
DC Operated Strobe Light	Electrical
Dynamics and Vibrations	Mechanical
Fluid Mechanics	Mechanical
Thermal Sciences	Mechanical
Introduction to Internet	General

Finally, a summary of the afternoon lectures given by various professionals is shown below:

Session Topic
Mathematics and Engineering
Science and Engineering
Team Building
Preparation for Six Flags
Introduction to Civil Engineering
Earthquakes
Environmental Engineering
Introduction to Electrical Engineering
Introduction to Mechanical Engineering
Communication
Society and Technology
Automated Highway
Transportation Overview

The program concluded with an Engineers' Panel Discussion and a Recognition Ceremony held on Friday, August 4, 1995. Both the participants and their families were invited to attend this final event. The morning session consisted of a panel of engineering professionals who discussed their reasons for becoming engineers and their resulting careers as practicing engineers. The panel consisted of representatives of all three engineering majors and included women and African-Americans. In addition, a panel of current engineering students enrolled in the Joint Program discussed their reasons for selecting engineering as their major and their experiences in the Joint Program to date.

Program Evaluation

Based on successful completion of the program, the Access to Engineering Summer Institute was very successful. Of the 37 students who started the institute, one dropped out and 32 of the 36 remaining students successfully completed the program (i.e., they received a C or better in their respective mathematics course).

Four of the six students who were high school graduates (two Caucasian females and two African-American males) enrolled as freshman in pre-engineering at UM-St. Louis in the Fall 1995 semester. Twenty-six students returned to their high schools to complete their senior years and are still eligible to receive a one-year scholarship to begin their pre-engineering studies at UM-St. Louis during the 1996-97 academic year.

Course Evaluations

Students were asked to evaluate the precalculus and calculus I courses two times during the program, once in the fourth week of the program and again on the last day of the program. Students were told that their responses were completely anonymous and confidential, and would be used to improve the course.

Names did not appear on the rating forms, that were distributed by a staff assistant. Students were asked to indicate on a five-point scale how much they agreed or disagreed with the following statements:

1. My high school course work prepared me for this course.
2. In general, the professor presents the material in a well organized manner.
3. In general, the teaching assistant is very helpful.
4. The course is challenging.
5. So far, I have learned a lot in this course.
6. The homework helps me prepare for exams.
7. The amount of study time on campus is just right.
8. The professor is covering the material too quickly.

They were also asked to indicate how many hours per week they spent outside of class working on the course and the grade they expected to receive. Twelve students evaluated the calculus I course in the fourth week, 23 students evaluated the precalculus course in the fourth week, 9 students evaluated the Calculus I course at the end of the course, and 23 students evaluated the precalculus course at the end of the course. The means and standard deviations of each item are presented in table 7 below. Higher scores indicate more positive ratings (item 8 was reverse scored so that higher values represent more positive evaluations).

Table 7. Precalculus and Calculus Course Evaluations

	Precalculus			
	Time 1		Time 2	
	Mean	SD	Mean	SD
1. Prepared	4.04	0.98	3.74	1.29
2. Organized	3.57	0.95	3.04	0.83
3. Helpful	4.26	1.01	4.09	0.79
4. Challenging	4.09	1.04	4.44	0.66
5. Learned	3.26	1.01	3.61	0.99
6. Homework	3.57	1.01	3.39	1.03
7. Study time	2.87	1.36	2.39	1.08
8. Too quickly	2.49	1.59	3.40	1.27
9. Hours	5.89	4.81	8.58	5.43
10.Grade (0-4)	3.17	0.65	2.67	0.86

	Calculus I			
	Time 1		Time 2	
	Mean	SD	Mean	SD
1. Prepared	4.58	0.90	3.78	1.39
2. Organized	3.92	1.00	3.44	1.24
3. Helpful	4.67	1.16	4.44	1.33
4. Challenging	4.75	0.62	4.33	1.00
5. Learned	4.58	0.67	4.44	0.73
6. Homework	3.64	1.29	3.13	1.46
7. Study time	3.42	1.38	3.89	0.93
8. Too quickly	1.33	1.37	3.06	1.39
9. Hours	9.62	3.10	5.69	2.39
10.Grade (0-4)	3.75	0.45	3.44	0.73

Focusing only on the items directly related to the teaching aspects of the course (2-6 and 8), the ratings were quite high for both the precalculus and the calculus courses, both at time 1 and time 2. At time 1 for the precalculus course, the helpfulness of the teaching assistants was rated highest, and the lowest rating was for how quickly the material was being covered (i.e., too fast). The calculus I course was rated highest for its challenging aspect, and lowest for how quickly the material was being covered. At time 2, the precalculus students rated the challenging aspects of the course the highest and how much the homework helped them prepare for exams the lowest. At time 2, the calculus course was rated highest for the helpfulness of the teaching assistant and how much the students had learned. Once again, it was rated lowest for how quickly the material was being covered.

In order to compare the success of the two courses, and to determine whether or not there were changes from the first to the second rating, a series of two-way analyses of variance (ANOVA) were conducted with the course (calculus or precalculus) and when the evaluation was conducted (time 1 or time 2) as the independent variables, and all of the rating scales as dependent variables. The results of this analysis are summarized in Table 8.

Table 8. Summary of Two-way ANOVA: Effects of Time and Course on Course Evaluations

Dependent Variable	Effect of Time	Effect of Course
Prepared	None	None
Organized	None	None
TA’s helpful	None	None
Challenge	None	None
Learned	None	Calculus I more positive*
Homework	None	None
Study Time	None	Calculus I more positive*
Cover Material	None	None
Hours student	None	Precalculus study more*
Expected grade	Lower at time 2*	Calculus I expect higher*

*Significant at .05 or better.

Overall, calculus students felt they had learned more than the precalculus students as reflected in the adjusted least square means (ALS means) of 4.6 and 4.2, respectively. They were more likely to think that the amount of study time on campus was just right, (ALS means = 3.6 and 2.6); they spent less than half as much time studying off campus, (ALS means = 3.2 and 7.2); and they expected to receive much higher grades (ALS means = 3.6 and 2.9). The only statistically significant change that occurred over time was in the grade the student expected to receive. It dropped from an ALS mean of 3.5 at time 1 to 3.1 at time 2.

Evaluation of Afternoon Activities

All afternoon activities were evaluated on a daily basis by program participants. Evaluation forms were completed the morning after the activity. In all, 13 labs (for a total number of student responses, N, equal to 468), 12 field trips (N=361), and 13 presentations (N=334) were evaluated. Participants were asked to rate each activity according to: how challenging they thought it was; how much it helped them to understand the field of engineering; how interesting they thought it was; how well organized they thought the activity was; the clarity of the presentation; and whether or not they would want to participate in the same activity (or one like it) again. Each item was rated on a five-point scale, with higher ratings indicating more positive reactions. The evaluations were presented to the staff on a weekly basis, so that the data could be used to improve the content of the program while it was still in progress.

In order to determine whether the types of activities were rated differently and whether being in a particular class had an effect, two-way analyses of variance were conducted with type of activity (labs, presentations, field trips) and course (calculus or precalculus) as the independent variable and all the evaluation criteria as dependent variables. Overall, the ratings for all three types of activities were quite high. Adjusted activity means can be found in Table 9. Based on student evaluations, labs were by far the most successful type of activity. They were rated significantly higher than field trips or presentations on every evaluation criterion except clarity, where they were rated higher than field trips but not presentations. Presentations were rated higher than field trips on the variables of challenging, helped to understand the field of engineering and organization. Field trips were rated higher than presentations for interest.

Table 9. Evaluations of Types of Activities: Adjusted Least Square Means

		Type of Activity	
Dependent Variable	Lab	Presentation	Field Trip
challenging*	3.82	2.87	2.37
understand*	4.16	3.74	3.49
interesting**	4.22	3.48	3.54
organized*	4.07	3.75	3.55
clarity***	3.97	3.82	3.67
do again**	4.20	3.44	3.46
N	468	361	334

According to Fisher's least-significant-difference test:
* all groups significantly different from one another at .05 level or better
** labs significantly different from field trips and presentations at .05 level or better
*** lab significantly different from field trips at .05 level or better

Whether the students were taking calculus or precalculus had significant effects (at a .05 level or better) on two of the evaluation criteria, organization and clarity. In both cases, calculus students rated activities more positively, possibly suggesting a greater level of sophistication among these students. There was one significant interaction between type of activity and course. Precalculus students gave labs higher ratings and calculus students gave presentations higher ratings. This suggests the possibility of a preference for "hands-on" activities among students at a somewhat lower academic level.

We were also interested in whether or not students considered the activities to be either too difficult or too easy. Accordingly, for each activity students were asked to indicate (yes/no) if it was too hard and if it was too easy. The three types of activities were cross-tabulated for each variable, and chi-squares were computed to determine if there were significant differences. Students were significantly more likely to say that the labs were too difficult (chi-square = 22.88; p<.001), but this accounted for only 8% of all lab evaluations. On the other hand, students were much more likely to rate presentations (22%) and field trips (22%) as too easy (chi-square = 58.17; p<.001). Accordingly, the success of the labs may have been due at least in part to an appropriate level of difficulty.

Evaluation of Specific Afternoon Activities

Specific activities were also evaluated within type. Figure 1 shows the means of overall ratings (the mean of the six evaluation criteria) of the labs. Certain labs stand out as particularly well received or not well received by students. The two highest rated labs were the environmental monitoring lab and the three-way switch lab. In the environmental lab, students were instructed on how to measure the amount of a specific pollutant to determine if it exceeded safe levels. The three-way switch lab challenged the students to design and wire two on/off electrical switches to operate a single light bulb similar to the type of connections found in their homes and schools.

The two labs which were rated lowest were the fluid mechanics lab and the Internet demonstration. The fluid mechanics lab consisted of the students measuring liquid viscosity with a capillary viscometer and calibrating a weir in open channel flow. In the Internet demonstration, students were given some introductory explanation of the structure, function, and capabilities of the Internet and world wide web engines. After visiting some particularly interesting web sites, students were set off on their own for a hands-on exploration.

Figure 1. Mean Values for Student Evaluations of Laboratories

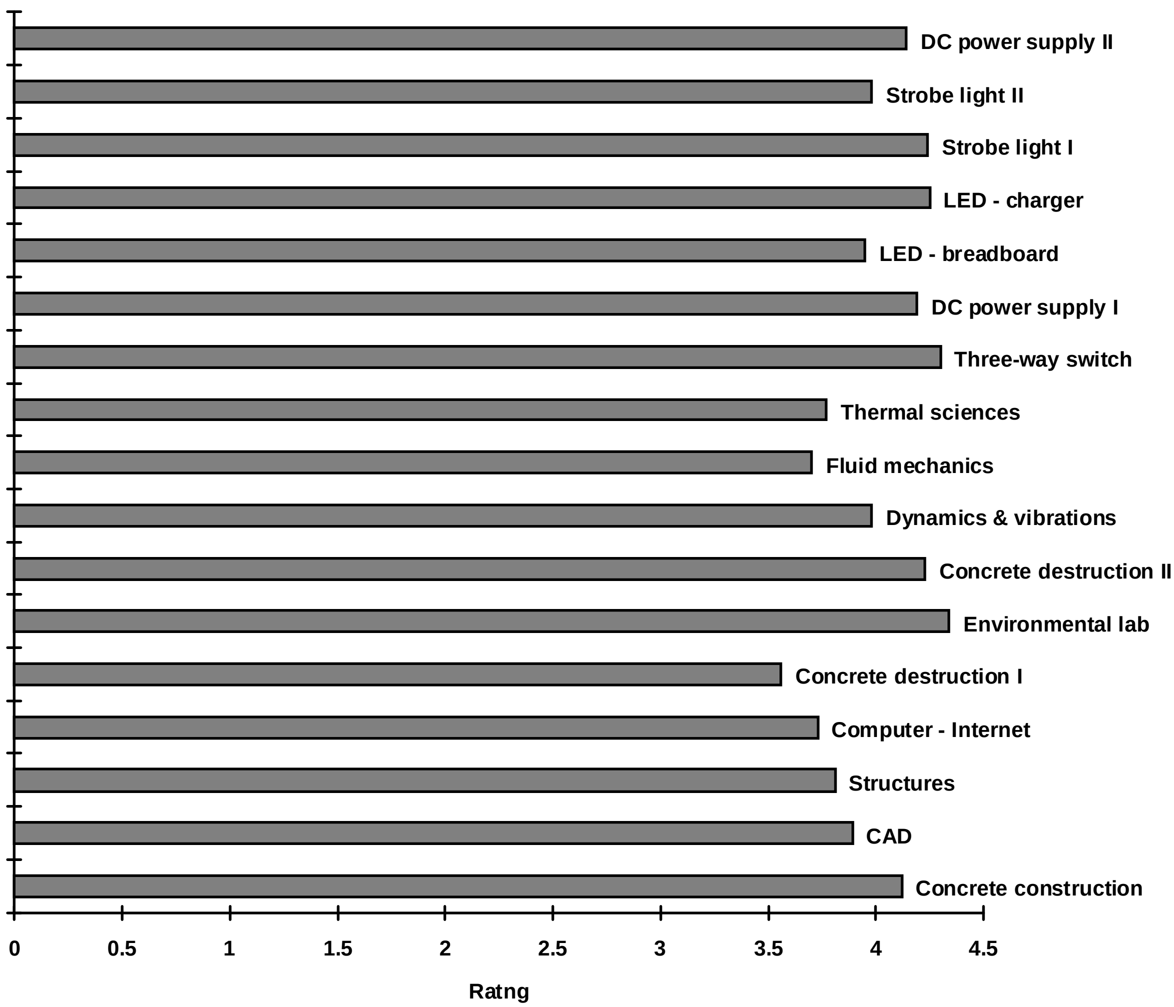


Figure 2 shows the means of the ratings for presentations. The “automated highway” and the environmental engineering presentations were rated highest. The automated highway presentation introduced students to the type of work and planning currently being conducted to support the “intelligent highways” of the future. The environmental engineering presentation discussed the air quality in the St. Louis metropolitan area relative to current EPA standards, compliance issues, and economic impacts.

The lowest ratings were for the “society and technology” and the “communication” presentations. The society and technology presentation consisted of an overview of the evolution of how people use and make tools. Most of the presentation consisted of a demonstration of primitive tool making. The “communication” presentation focused on identifying characteristics of good and poor written communications, and the importance of being able to effectively communicate with an audience. Perhaps it is not surprising that the two presentations that did not deal directly with the field of engineering were rated the lowest. However, it also underscores the need for designing challenging activities in related areas that will ultimately be important to successful engineering careers.

Figure 2. Mean Values for Student Evaluations of Presentations

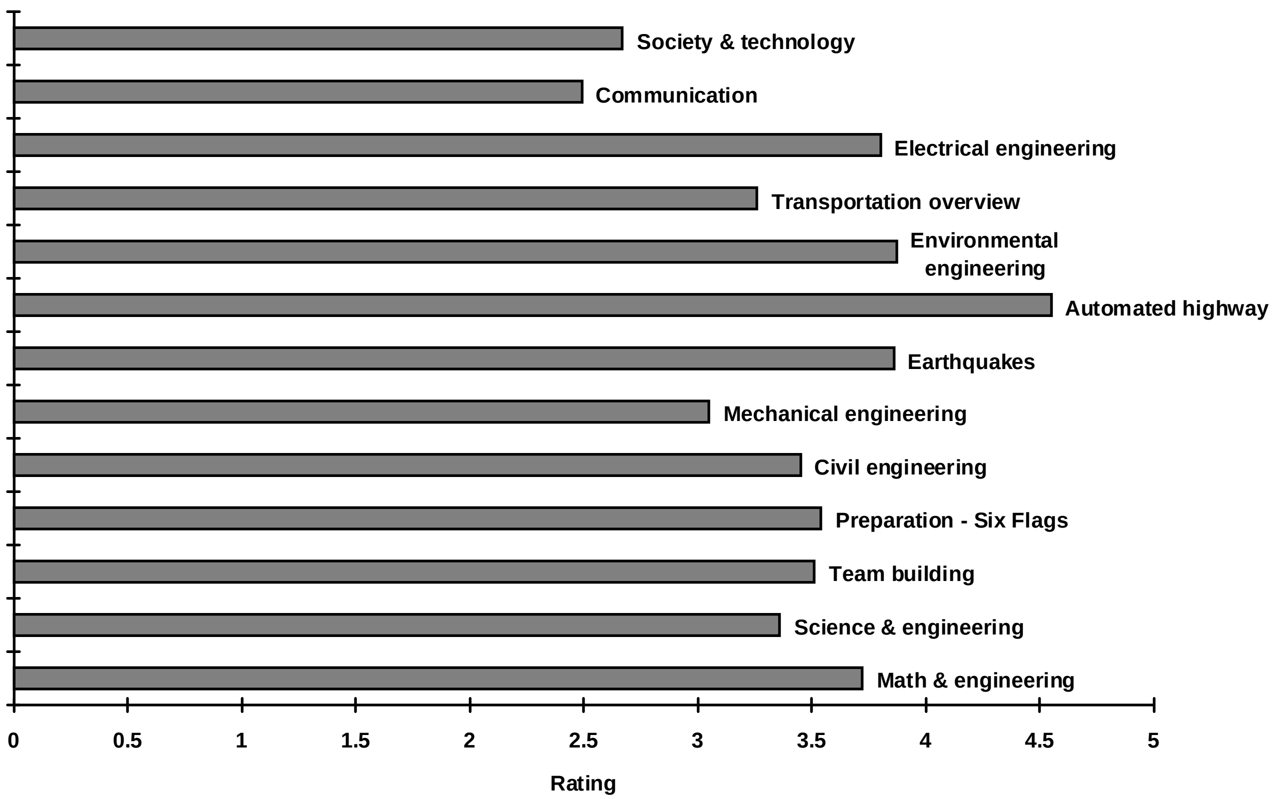
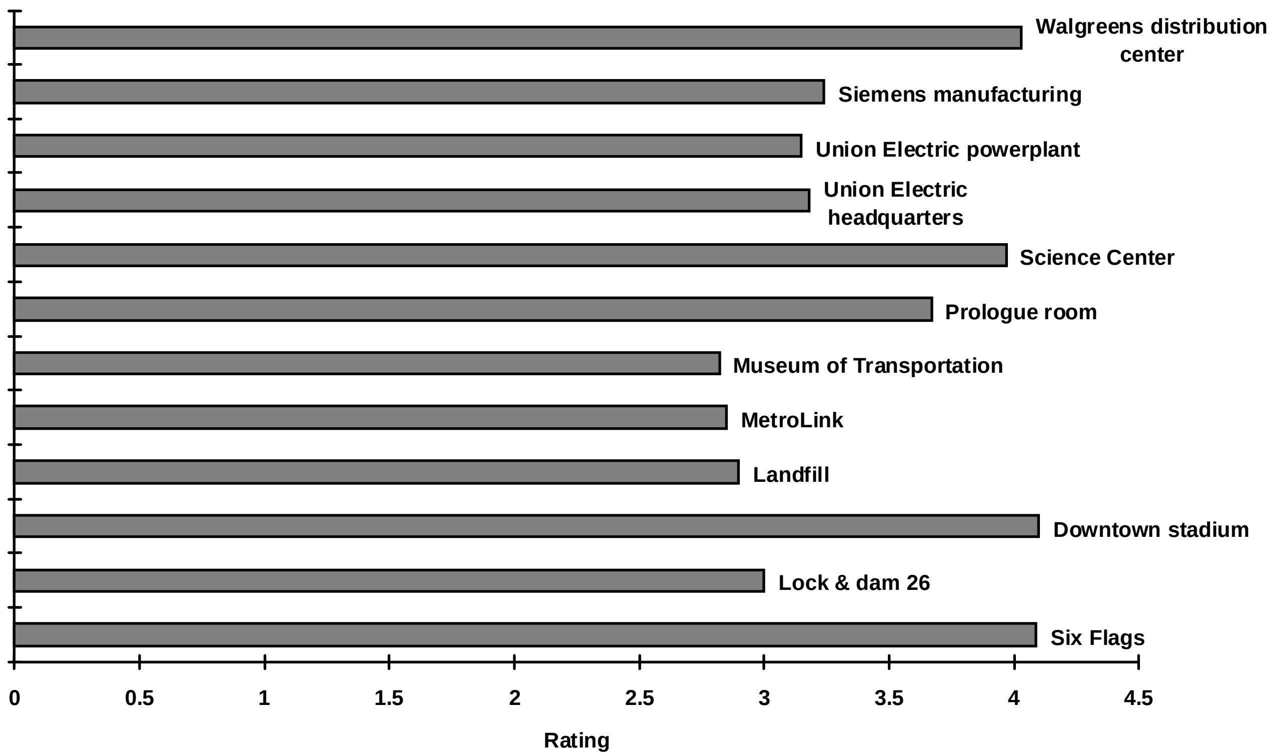


Figure 3 shows the means of the ratings for the field trips. The two field trips that were rated the highest were the tour of the St. Louis stadium construction site and the trip to Six Flags over Mid-America. The construction site tour of the new downtown St. Louis indoor football stadium provided the students with the opportunity to begin to appreciate the project and construction management requirements of building a large multi-story building, and to obtain a preview look at the new home of the St. Louis Rams football team before it was open to the public. The Six Flags trip combined some work, making specific measurements in the morning, with just plain fun at an amusement park in the afternoon.

The least successful field trips were the ride on MetroLink and the Museum of Transportation. The MetroLink field trip consisted of a presentation of the history and construction of the initial phase of the St. Louis light rail system, followed by a round-trip ride to one end of the system from the university stop. The Museum of Transportation is a public facility focusing on the history of planes, trains, and automobiles with a special tour of the locomotive passenger and freight trains section provided to the students. Overall, field trips that had an obvious connection with engineering and sites that are not generally available to the public seemed to be received more positively. The findings also underscore the need for staff to make explicit connections between the activity and engineering when the connection is not apparent.

Figure 3. Mean Values for Student Evaluations of Field Trips



Summary and Conclusions from the 1994-95 Program

A determination of the level of success achieved by the 1994-95 McDonnell Douglas Access to Engineering Summer Institute can only occur based on the number of participants who enroll and successfully complete an undergraduate engineering curriculum. However, we feel confident in judging the program a success based on virtually every measure currently available. The program reached its target population of under-represented minorities and women, with an outstanding number of qualified applications in its first year. Student performance and retention were excellent, with 89 percent of the students completing the program successfully and qualifying for full-tuition scholarships for their freshman year as pre-engineering students at UM-St. Louis. Four of the six students who were eligible to do so enrolled at UM-St. Louis in the fall of 1995.

Student satisfaction, as reported in evaluations of the morning course work and afternoon activities (laboratories, presentations, and field trips) was also strong.

Nonetheless, the first year of offering the McDonnell Douglas Access to Engineering Summer Institute was a learning experience for us as well as for the students who participated. There are several conclusions we have drawn that will influence revisions to any similar future programs we may have the opportunity to offer. In brief, these were:

1. Eight weeks is a long time to maintain a high level of interest and enthusiasm on the part of the participants. However, an eight-week period may be necessary to allow educational objectives to be met in the morning mathematics course work. One solution may be to have the courses meet four days per week (Monday through Thursdays), as we did with the calculus I course this year.

2. Consistent with research on other pre-collegiate programs (National Council for Minorities in Engineering, 1987), afternoon sessions that were "hands-on" or that permitted the students to experience something not available to the general public were clearly rated highest. A set of afternoon sessions focused on the highlights of the events we included this year and matching the criteria for success we identified in our analysis should provide a highly effective means for meeting our objective of introducing the students to engineering.

3. An introductory session focusing on team-building, group dynamics, and establishing an early spirit of camaraderie among the participants is important. While we did this as a single session during the first week of the program, a more extensive experience that focuses on the diversity of the participant group and the diversity of the engineering workforce might be able to accelerate the rate at which the group established its own identity. Perhaps this can be incorporated into a series of professionally supervised activities that could occur before the formal program actually begins.

4. The success of this program supports the notion that participants in engineering enrichment programs need not be only the "cream" in order to succeed (Wiley, 1989). A broader base of students can and should be recruited to these programs, and ultimately to the field of engineering.

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