A Descriptive Study of College Minority and Majority Students' Attitudes Toward Engineering Courses and Peer Study Groups

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PURPOSE AND OBJECTIVES

The purpose of this study is to summarize a description of perceptions of undergraduate minority and majority engineering students regarding their self-concept as learners and study skills, and their attitudes toward instructors, classmates, and cooperative learning strategies. Information was collected using a survey and interviews, and data was analyzed descriptively leading to patterns of undergraduate minority and majority engineering students' educational problems, needs, and attitudes. Then, it is our objective to document students' educational problems and needs when taking required courses that demand high level conceptual thinking and problem solving skills. A large portion of students taking two courses offered at the Systems and Industrial Engineering Department (SIE) at The University of Arizona (UA) (i.e., SIE 230: Introduction to Probability, and SIE 270: Introduction to Engineering Computation) volunteered to complete the survey. These two courses are required for several majors at the College of Engineering & Mines at the UA, and many students from science majors take them as electives. These are very demanding and fast-paced gatekeeping courses, requiring advanced mathematics and computing skills. Several peer study groups for underrepresented minority students, sponsored by the Coalition to Increase Minority Degrees (CIMD), a NSF-AMP funded project, were organized and coordinated by Prof. Fernández. In addition, minority students participating in these peer study groups were invited to volunteer for an interview.

BRIEF RATIONALE AND BACKGROUND

It is well known that (e.g., see Bradley-Stonewater, Stonewater, & Hadley, 1986; Erwin, 1983; Perry, 1970) instructors' understanding of students' attitudes, educational problems, and needs improves the quality of education. Engineering courses deal with complex computing mathematical problems that require high levels of conceptual thinking, self awareness of study skills, and positive attitude development toward cooperative learning strategies (see e.g., Bennett, Niggle, & Stage, 1990). The delivery of information at an academic level is not enough to help students achieve the needed higher conceptual levels leading to problem solving skills in courses related to conceptual foundations of engineering. Thus, there is a need to stimulate students to think, discuss, and develop higher level conceptual skills using, e.g., cooperative learning strategies.

The instructor can serve as a guide for discussing and constructing answers to mathematical problems leading to stimulating conceptual higher level thinking and helping students overcome their misconceptions. In addition, cooperative learning groups in which mentoring and reflective and critical thinking methods are used are important for developing students' higher cognitive skills in mathematical concepts. Developing targeted educational intervention programs is especially needed and recommended for underrepresented minority students in engineering, in which mentoring and advising are central activities that instructors need to provide (see e.g., Rodriguez, & Gallegos, 1981).

Presently, there is a major need for increasing the number of female and male underrepresented minority, and female majority students. The growth of minority female and male students enrolled in two and four year colleges does not reflect demographics during the 1981-1991 decade, as minority students are not graduating to the extent than majority students are (Chronicle of Higher Education Almanac, 1993). Many minority students attend two year colleges without trying to apply to four year colleges (American Council on Education and UCLA Higher
Education Research Institute, 1994). When the total number of degrees awarded in 1989 in science and engineering are broken down by ethnicity, White students were awarded 77.7% of the degrees, versus 8% to Asian-Americans, 4.1% to African-Americans, 3.8% to Hispanics, and .7% to Native-Americans (National Science Foundation, 1990).

When serving minority college students instructors need to be familiar with at-risk factors such as potential school dropout and under achievement (Kasten & Hoewe, 1988), low socioeconomic level, non-participation in high school academic programs, and low transfer rates from two to four year higher education institutions (Rendon & Triana, 1989). Minority students may not enter college and pursue a bachelors' or graduate degree in engineering due to lack of economic and educational opportunities. For instance, as reported by the National Science Foundation (1992) family incomes of Hispanic and African-American freshmen are much lower than majority students. In addition, the level of their parents' education is also much lower for minority freshmen than for majority counterparts, which may influence parental attitudes and expectations towards higher education (National Science Foundation, 1992). Grade point averages also tend to be lower for minority than for majority students (National Science Foundation, 1992). However, the minority students who are already pursuing a bachelor's engineering degree tend to pursue graduate studies, perhaps due to resilience as these students had to overcome so many barriers to go through college.

Some minority students are able to stay in high school and even go on to college, but suffer from important conceptual foundations deficiencies in their mathematical education that negatively influence their academic achievement in engineering undergraduate courses (Kasten & Howe, 1988). These minority students are at-risk of not developing adequate mathematical knowledge and skills as they come from lower academic backgrounds in comparison to majority students; and they also show lower self-esteem, task performance, achievement levels, and career aspirations (Kasten & Howe, 1988). Henderson and Landesman (1994) reported that aspirations and expectations, as well as instrumental knowledge of the educational requirements necessary for pursuing career aspirations for their children held by Hispanic parents are potential influences on students' achievement and motivation. According to Henderson and Landesman (1994) resources and support that Hispanic parents could provide to their children were also important factors affecting students' academic performance.

Furthermore, some minority students also speak English as their second language and may lack English proficiency in comparison to Anglo middle-class students. Several students have been conducted in relation to translational skills for problem-solving in mathematics. Translational math skills have been defined by Gerace and Mestre (1988) as the ability to translate verbal statements into mathematical equations, and vice versa. For instance, Short and Spanos (1989) stated that "it is obvious that a lack of proficiency in the language of instruction has harmful effects on a students' ability to deal with content-area texts, word problems, and lectures." Moreover, Short and Spanos (1989) also argued that "the nature of math and science language imposes a heavy burden on all students regardless of language of instruction". Then, if both factors (i.e., lack of English proficiency and mathematical specialization language) occur in a formal learning situation, then language-minority students suffer from a double burden on their academic achievement when taking undergraduate engineering courses. There is also evidence that bilingual Hispanic engineering students' technical skills are strongly correlated with linguistic skills; and that their performance is strongly influenced with the amount of verbal information processed, which is evidenced in unique error patterns leading to improper setting up of the problem due to language misinterpretations (Gerace and Mestre, 1981: Mestre, 1981, 1984).

In conclusion, minority college students are at-risk due to the influence of additive internal and external factors effecting their achievement levels in engineering courses such as their gender, their self-esteem and self-concept as learners, their general and technical English language proficiency levels, their parents' educational and socioeconomic status, their parents' and instructors' attitudes and expectations towards career choice and educational challenges, the curriculum and program they were exposed to during elementary and secondary school, etc. These numerous internal and external factors affecting academic performance can be overwhelming for minority college students, leading to drop out and failure when taking demanding gatekeeping engineering courses. Thus, In this study we propose that the presence of instructors and peers who act as mentors is key for developing resilience, study skills, and learning and coping strategies in minority college engineering students.

METHODOLOGY

Subjects. The total number of students enrolled during the Spring 1994 semester in SIE 270 (N=45) and SIE 230 (N=90) were invited to participate; from which 118 students volunteered to sign a consent form explaining the purpose of the study, and completed a survey. The second author of this paper, Dr. Fernández, was the instructor for SIE 270; and Dr. Frank Ciarella was the instructor for SIE 230. The majority of students fall within the range of 19-21 years-old (n=49, 41.5%), 39 students (33.1%) were in the range of 22-25, 25 (21.2%) students were between 26-30 years of age, and 5 students (4.2%) were over 30 years of age. Ninety three students (78.8%) reported to be permanent residents or citizens of the United States, primarily from the Southwest (n=56, 47.5%) and from an Anglo ethnic background (n=53, 45%). There was a total of 38 students (32.2%) from a minority ethnic
The majority of students reported to be juniors (n=67, 56.8%), 34 students reported to be sophomores (28.8%), 14 students reported to be seniors (11.9%), and 3 students (2.5%) reported to be freshmen. Fifty six (47.5%) students reported to be transfer students primarily from Arizona Community Colleges (e.g., Pima, Cochise) and the California State University System (e.g., Fresno). The majority of students reported a G.P.A. prior to the Spring 1994 semester as 3.5-4.0 (n=49, 41.5%), followed by 2.5-3.0 (n=43, 36.5%). The majority of students were majoring in Electrical (n=19, 16%) and Computing Engineering (n=10, 8.5%). Most students had decided upon their majors, but a large proportion (n=40, 33.9%) have changed their majors at least once.

In addition, 5 minority students who were participating in the peer study groups volunteered to be interviewed. A total of 7 peer study groups were organized, consisting mostly of two students each, giving a total of 13 students (about one third of the total number of minority students in the two classes surveyed). These students met about three times a week for periods of about one to three hours, and more intensively before scheduled exams. When minority students participating in the peer study groups were asked what language was spoken most often at their home while they were at elementary and secondary school, 10 students (76.9%) reported Spanish as their primary language during childhood and adolescence. The most common first language reported was Spanish (10 students, 76.9%), with 1 student (7.7%) reporting Vietnamese as his first language; and 3 students (23.1%) reporting English as their first language.

Five students (38.5%) participating in the peer study groups were females (in comparison with 17.8% of the total number of students in the two undergraduate engineering classes surveyed), and 8 students (61.5%) were males (in comparison with 82.2% of the total number of students in the two undergraduate engineering classes surveyed). The over representation of females in peer study groups is an interesting event to highlight. As reported above, a number of studies have documented the additive at risk situation that female college engineering students need to overcome; which may explain their under representation in engineering fields, and their over representation in peer study groups organized in this study.

When minority students participating in the peer study groups were asked in the biographical forms if they had worked in the summer during high school, and/or between high school and college, 3 students (23.1%) reported that they had worked between 11-20 hours per week, 6 students (46.2%) reported that they had worked for more than 20 hours per week, and 4 students (30.8%) reported that they had not worked. When these students were asked if they had worked in the academic year during high school, 2 students (15.4%) reported that they had worked between 5-10 hours per week, 3 students (23.1%) reported that they had worked between 11-20 hours per week, 4 students (30.8%) reported that they had worked for more than 20 hours per week, and 4 students (30.8%) reported that they had not worked. When these students were asked if they have worked in the summer during college, 2 students (15.4%) reported that they have worked between 1-10 hours per week, 2 students (15.4%) reported that they have worked between 11-20 hours per week, and 8 students (61.5%) reported that they have worked for more than 20 hours per week, and 1 student (7.7%) reported that he has not worked. When these students were asked if they had worked in the academic year during college, 4 students (30.8%) reported that they have worked between 1-10 hours per week, 5 students (38.5%) reported that they have worked between 11-20 hours per week, and 3 students (23.1%) reported that they have worked for more than 20 hours per week, and 1 student (7.7%) reported that he has not worked. Thus, most of the underrepresented minority students had to work during high school and college throughout the year.

When asked about their majors, the majority of students in peer study groups identified their major as Electrical Engineering (n=7, 53.9%). Other majors were identified as well, Industrial (n=2, 15.4%), Mechanical (n=2, 15.4%), and Computing Engineering (n=1, 7.7%); and Optical Sciences (n=1, 7.7%). The minority students participating in peer study groups reported a lower grade point average in comparison to the total number of students participating in the survey. Ten minority students (76.9%) reported their cumulative grade point average prior to the Spring 1994 semester to be in the 2.00-3.0 rank, 5 students (38.5%) fall within the 3.00-3.29 rank, and 2 students (15.4%) fall within the 3.30-4.00 rank.

Instruments and Activities. A written survey was designed by the first and third author of this paper using 1 open-ended, and 25 closed-ended questions (5 questions were multiple-choice, 9 questions were affirmative-negative dichotomous questions, and 11 questions used Likert Scales). These 36 survey questions were divided in four areas: (1) demographics, (2) students' perceptions about their self-concept as learners and their study skills, (3) students' attitudes toward their instructors and classmates, and (4) students' attitudes toward cooperative learning strategies.

In addition, an open-ended interview was designed to give minority students participating in cooperative learning groups the opportunity to express their attitudes, problems, needs, and experiences. The students who volunteered to be
interviewed were asked questions regarding their backgrounds and attitudes towards their classmates, instructor, and cooperative learning strategies, which expanded survey questions.

Minority students in the SIE 230 peer study groups were given copies of extensive lecture notes prepared by Dr. Fernández, they reviewed and discussed material covered in both courses, exchanged ideas regarding homeworks and computational experiments.

Procedure. Students taking the SIE 230 and SIE 270 courses were informed by their instructors regarding the descriptive study and were invited to participate on a voluntary basis. Students were informed orally and in writing in the consent form that their participation in the study would not prejudice their course grades or overall performance in the course; and that even if they signed the consent form they could discontinue their participation at any time. Students who volunteered were asked to sign a consent form stating that they had decided to release the information collected through the survey for a research study that would report group anonymous data. The survey data was collected at the beginning of the semester during regular class meetings.

The interviews were conducted at the end of the semester, for which the 15 minority students participating in peer study groups were invited. Five minority students volunteered to be interviewed for 30 minutes outside class time in a quiet office. In addition, class naturalistic observations of SIE 230 were conducted by the third author of this paper by the end of the Spring 1994 semester. The purpose was to examine the educational environment offered by the instructor and the interactional patterns between students and the instructor.

RESULTS AND DISCUSSION

Survey. Students' perceptions of their self-concept as learners, the majority of students felt assertive (96.6%) but anxious (80%) most of the time; overwhelmed (50%), motivated (60%), and committed (90%) almost always; confident only sometimes (43%); and perceived themselves as experienced (47%). Thus, the majority of the students had contradictory feelings about their self-perceptions, as they felt at the same time overwhelmed and anxious, but assertive and motivated. In reference to the students' perceptions about their study skills, 76% of students had never taken a course related to culture or gender issues, and 91% of students had never taken a course in learning strategies or study skills. The majority of students almost never study in groups (37%), like to eat and drink when they study (43%), and most often study at the dormitory or apartment (65%). The majority of students reported to devote between one and five hours per week to study the material for each of these courses (66%). Thus, we can observe that students lack training in study skills and were not inclined to collaborate in learning groups. Regarding the students' attitudes toward the instructor, the majority of the students describe the attitude of their instructor as committed (69%), experienced (75%), open minded (35%), helpful (66%), fair (38%), supportive (35%), and enthusiastic (34%) most of the time.

Most of the students had never visited their instructor or teaching assistant during office hours (48%), of if they had visited them had done so less than three times during the semester (27%). Students gave as reasons for not visiting their instructors and teaching assistants: no need, no time, inconvenient office hours, and the presence of study groups for help. The majority of students almost never participated in class (33%) because they considered that there was no opportunity, there was no need, they were too shy, they had language difficulties, or did not feel motivated to participate. Thus, less one-to-one contact than desired had taken place during the semester, in part due to the presence of a large number of students in each class. However, the existence of peer study groups helped to alleviate the need of individual contact between instructors and students.

Most students (52%) had participated in organized group activities and met at least once a week. Students who reported not participating in group activities, gave as reasons for not involvement: no time, unfamiliarity with the existence of group activities, absence of social skills, and lack of interest and motivation. Thus, the population was divided into a group of students who had positive attitudes towards group activities and were inclined to participate in them, and another group of students who dislike group activities and were not willing to engage in them.

Interviews given to minority students participating in peer study groups. This information helped to expand on survey responses. Two students reported that they preferred to study alone, although they say that the peer study group was helpful to them. These same two students spoke positively about group involvement and expressed a change in their level of commitment and accomplishment. Another student felt much older and more mature than his peers. This same student felt that it was easier for him to study alone. Another student was completely enthusiastic about working in groups, and reported that it was the only way to truly learn well. Another student reported that she had perceived some attitudinal bias in classmates and instructors she had in the past due to his minority status. Another student reported her perception of the educational environment as being competitive. Yet, another felt that establishing friendships can help to perceive the educational environment as less competitive.

Class naturalistic observation. The SIE 270 naturalistic observation focused on a description of the classroom
environment, the students' and instructor's behaviors. The class was a fairly big lecture hall with rather small desks distributed very close together. Each desk was facing the front of the room where a wall is adorned with a big screen placed before an overhead projector. Few students sit towards the front, most are concentrated towards the middle of the hall and some students sit in the back of the room. As they enter the classroom, students placed previously assigned homework on the instructor's desk.

The instructor began the class by calling out the names of students who needed to come to the front of the room to receive their graded exams. Some of the students were not present and the instructors exhibited a sense of humor by commenting that they were still on vacation (as spring break had just passed). The instructor used a microphone and an overhead which helped to make the lecture hall feel smaller. The instructor introduced class objectives, while some students were still talking. Then, the instructor asks these students to please be quiet, and the students were receptive and the class was silent as students are intently listening to their professor. The task set by the instructor was to review homework using an overhead projector with typed pages that are difficult to read by students sitting in the back of the room. The instructor acknowledges that the overhead sheet may be difficult to read, so that he uses a color pen to underline an algorithm that he was discussing. This is very helpful and compensates for a hard to read overhead while he illustrates in detail and depth how to work out a problem. He uses his pencil as a pointer and is consistent in giving positive reinforcement.

Regarding instructional methodology, the instructor was able to relate prior knowledge of students in relation to what he was explaining. This immediately gave the students something they could related to, and an idea of how to approach the problem. A practice test was distributed by the instructor to the students, which enabled the students to gauge their understanding of the content material and to give them direction and focus before they are graded. Students were also advised by the instructor where to find information they needed for studying and practicing. Due to the mechanical nature of the problems that were reviewed, they were discussed in the context of steps rather than on strategies.

Regarding the interaction between the instructor and the students, it is important to highlight that the instructor showed that he knew many of the students and addresses them by their first name. Each question posed by a student is treated with respect and is addressed until the student understands. The professor speaks slowly and clearly, and he displayed a helpful sense of humor. Overall, the performance of this instructor in the class was described by the observer, the third author of this paper, as clear, well paced, fair, and considerate. Students were observed to be at ease and there seemed to be a mutual respect between teacher and student.

Examining the results obtained in this first exploratory-descriptive study, we can identify new issues for future studies including: (1) the role of general and technical English, and of symbolic mathematical language proficiencies on performance in engineering courses, (2) the need to collect more data on socioeconomic background of minority students and its effects on academic achievement in engineering courses, and (3) to study the effects of perceptions of minority female students about their parents' and instructors' academic expectations.

OBSERVED LIMITATIONS

Although a group of 13 minority students consistently participated in the peer study groups, many others only came in for help and guidance right before the exams, or when faced with very difficult assignments. A possible cause for this selective participation could have been that this was the only the second time a CIMD-sponsored peer study group project was offered for these courses, minority students were somewhat doubtful of the benefits they would obtain from their participation.

ACKNOWLEDGMENTS

The work reported here was made possible through grants F93UR031 and S94US041 from the Coalition to Increase Minority Degrees (CIMD). The second author also acknowledges the support of The Engineering Foundation under grant RI-A-93-10.

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**BIOGRAPHICAL SKETCHES**

Virginia González earned her Ph. D. in Educational Psychology from The University of Texas at Austin in December 1991, and became an Assistant Professor at the Department of Educational Psychology at The University of Arizona in August 1992. Her research focuses on the assessment of cognitive-language development of bilingual minority students, work for which she has received two dissertation awards (National Association of Bilingual Education, NABE, 1992; and American Psychological Association, APA, 1993). She has received a certificate of recognition from Psi Beta, National Honor Society in Psychology for Community and Junior Colleges; for her contributions to mentoring minority students at the Diversity Project 2000 Summer Institute, co-sponsored by APA, in 1994.

**Emmanuel Fernández-Gaucherand** obtained a Ph.D. in Electrical and Computer Engineering from The University of Texas at Austin in August 1991. Since then he has been an Assistant Professor in the Systems and Industrial Engineering Department at The University of Arizona. His teaching and research interests are in the areas of stochastic systems and control and software system development. He has over 34 refereed archival publications in these areas. He was named "1993 - 1994 Professor of the Year" by the Arizona Alpha chapter of Tau Beta Pi at the University of Arizona.