Barriers to minority women in undergraduate engineering programs

by

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CHAPTER ONE

INTRODUCTION

Traditionally, engineering and the natural sciences have been fields dominated by white men. This is evident in the severe under-representation of both women and minorities in engineering and science related careers. At the present time, women represent approximately 7.3 percent of engineering professionals (Robinson and McIlwee, 1992). Correspondingly, African-Americans constitute approximately 2.6 percent of the science and engineering work force (National Science Foundation, 1990). Between the years of 1980 and 1989, the number of engineering degrees awarded to women and minorities increased dramatically. Table 1.1 illustrates the numeric and percentage rise in the number of baccalaureates earned by women and minorities. Table 1.2 demonstrates the percentage of baccalaureates earned by women and minorities relative to the total number of degrees awarded in 1980 and 1989.

In spite of the apparent increase in the numbers of women and minorities earning degrees in engineering, both groups remain under-represented in all engineering disciplines relative to the number of women and minorities in the United States workforce. This phenomenon has been attributed to significant obstacles which women and minorities confront throughout their educational careers. These barriers ultimately inhibit the recruitment and retention of women and minorities in engineering programs.

Table 1.1 Engineering degrees earned by women and minorities in 1980 and 1989

	1980	1989	% Increase
Women	931	1036	11.3
African-Americans	158	170	7.6
Hispanic-Americans	257	274	6.6
Asian-Americans	290	353	21.7
Native-Americans	9	28	211.0

Source: American Society of Civil Engineers, 1990 in NCHRP Project 20-24(3), 1992)

Table 1.2 Percentage of engineering degrees earned by women and minorities relative to the total number of baccalaureates conferred in 1980 and 1989

	1980	1989
Women	9.0%	13.0%
African-Americans	1.5%	2.2%
Hispanic-Americans	2.5%	3.6%
Asian-Americans	2.8%	4.6%
Native-Americans	>0.1%	0.3%

Source: American Society of Civil Engineers, 1990 in NCHRP Project 20-24(3), 1992

Statement of the problem

Women and minorities encounter barriers at all levels of the educational system which inhibit them from achieving careers in engineering. These barriers can be broken into two categories:

- Systemic obstacles which constrain the **recruitment** of women and minorities in engineering
- Systemic obstacles which constrain the **retention** of women and minorities in engineering

Systemic barriers which inhibit women and minority "recruitment" include:

- Race and gender biases of standardized tests (Berger, 1978; Zimmer Daniels, 1988; Ogbu, 1978).
- Placing perceived "college-bound" students into certain "tracks" alternative tracks (Boocock, 1978; Brischetto and Arciniega, 1973).
- Language barriers (Fickett, 1975; Gordon, 1988).
- Low participation of women and minorities in pre-college science and math courses (Baum, 1990; De Van Williams, 1990; Forbes and Edosomwan, 1990; Hoel, Francois, and Lloyd, 1243; National Science Foundation, 1990; Rawls, 1990).
- A lack of encouragement on the part of guidance counselors (Adams, 1988; Baum, 1990; Zimmer Daniels, 1988; Fulco and Dallaire, 1973; Meade, 1991; Russel, 1991; Tobin and Woodring, 1988).
- The fact that minority students often come from families unable to effectively support academic achievement due to a lack of educational experience of the parents (Bowles and Gintis, 1976; Gordon, 1988; Jencks et al, 1972).
- Inadequate financial assistance (Adams, 1988; Forbes and Edosomwan, 1990; Humphreys, 1988; Russel, 1991).

Systemic barriers which inhibit women and minority "retention" include:

- A lack of mentors and/or role models (Baum, 1990; Forbes and Edosomwan, 1990; Hoel, Francois, and Lloyd, 1243; Ivey, 1988; Tobin and Woodring, 1988).
- A sense of social isolation (Asbrand, 1986; Baum, 1990; Hayden and Holloway, 1985; Ivey, 1988; Landis, 1988).
- Unsupportive attitudes of advisors, teachers, parents and peers (Adams, 1988; Baum, 1990; Zimmer Daniels, 1988; Fulco and Dallaire, 1973; Meade, 1991; Russel, 1991; Tobin and Woodring, 1988).

- Lower teacher expectations of women and minority students as compared with their Caucasian male counterparts (Ivey, 1988).
- Low self-confidence (Stake, 1979; Tobin and Woodring, 1988).

Women and minorities clearly face numerous obstacles to their achievement of careers in engineering. Many of these barriers, unfortunately, fall into the "systemic obstacles to recruitment" category which essentially reflects problems inherent in our elementary and secondary educational systems. Battling this type of barrier requires a long-term effort and is, indeed, a necessary condition for the future recruitment of women and minorities into engineering careers. This thesis, however, will focus on the short-term, i.e., confronting the "systemic obstacles to retention" which essentially contribute to the high attrition rate of women and minority students presently in engineering programs. Since research on this subject has essentially treated the issues of gender and race as if they were mutually exclusive entities and fails to acknowledge the unique situation of minority women, this thesis focuses specifically on the experiences of minority women.

Hypotheses and organization of the thesis

The following thesis investigates the effects of "systemic barriers to retention" on minority women to ascertain whether minority women experience barriers to a more significant degree than do white women or minority men. The experiences of minority women, in turn, would lead to a higher rate of attrition within this group.

- Hypothesis 1:

  > Minority women experience "systemic barriers to retention" to a significantly greater extent than do white women and minority men.

- Hypothesis 2:

  There is a greater potential for attrition among minority women because they experience "systemic barriers to retention" to a greater extent than do white women and minority men.

Chapter Two discusses current literature on attrition rates for women and minorities in undergraduate engineering programs, the barriers women and minorities experience in undergraduate engineering programs, and how minority women experience attrition and the barriers. Sociological theory on the under-representation of women and minorities in engineering and, specifically on the inequitable educational experiences of lower-class, minority and female students is introduced in Chapter Three. Chapter Four describes data collection methods and statistical procedures utilized in the data analysis of Chapter Five. Chapter Six of this thesis is a summation of the results and an overall conclusion.

CHAPTER TWO

LITERATURE REVIEW

The under-representation of women and minorities in the field of engineering has sparked a plethora of research on the subject. The primary focus of this research has pertained to recruiting and retaining women and minorities in engineering and, more specifically, on the obstacles inhibiting the recruitment and retention of these groups in engineering programs.

As women and minorities traverse the educational pipeline, their interest in the natural sciences and engineering decreases to a greater degree than it does for Caucasian men (National Research Council, 1991). This phenomenon inhibits the recruitment potential for women and minorities in undergraduate engineering programs and, thereby, contributes to low enrollment levels of women and minorities into said programs. Those women and minorities capable of surpassing obstacles at the secondary education level and who enter engineering programs are confronted by a new class of barriers which ultimately inhibits their retention in said programs. It is this phenomenon which is the focus of the following discussion.

Women and minority attrition

The attrition rate of all students in undergraduate engineering programs is high. Hayden and Holloway (1985) and Greenfield and Holloway (1981) estimate only 50 percent of students entering undergraduate engineering programs actually receive their degrees in this field. For women and minorities enrolled in predominantly white universities, however, the rate of attrition is disproportionately higher. Given the low numbers of these

groups pursuing careers in engineering, the high attrition rate for women and minorities has even greater significance.

According to Landis, at predominantly white universities, "minority engineering students are retained at about half the rate of all students" (1988:756). In a study conducted by the College of Engineering at Michigan State University (the Sloan evaluation), researchers attempted to determine the extent to which minority students were being retained in engineering programs. Prior to the Sloan Project, between 1967 and 1974, "7 out of 10 minority students never completed an engineering degree" (Stonewater, 1981:176). After three years of the Sloan Project, during which time minority students were provided with curriculum assistance and counseling, the attrition rate for minority students remained at approximately 60 percent--paralleling the pre-Sloan rate of attrition (Stonewater, 1981). This is a clear indication there are significant barriers within engineering programs which minority students encounter that are beyond the scope of academic assistance and counseling. These obstacles will be identified and addressed in the pages ahead.

Similar to minority engineering students, women engineering students have a disproportionately high rate of attrition. A study of the retention of men and women engineering students conducted by Diederich Ott concluded "after 1.5 years of college, men and women engineering students in a population of 42 schools had different retention rates in engineering at their original schools" (1978:137). Based on a sample of students at 16 colleges and universities, the retention rates were determined to be equal for men and women at one school; higher for women than men at two schools; and higher for men than women

at thirteen schools. Furthermore, Diederich Ott determined that 68 percent of women as opposed to 43 percent of men not retained in the engineering programs were internal transfers: academic failure accounted for 10 percent of women as opposed to 24 percent of men in the nonretention group (Diederich Ott, 1978). These figures suggest that women are leaving engineering programs for reasons other than an inability to meet curriculum requirements.

Diederich Ott's assessment is consistent with the findings of Erickson in his study of 130 men and women Agricultural Engineering (AE) students. According to Erickson, "men and women AE's were found to have quite similar personal aptitudes", i.e., comparable abilities to handle requisite course-work (1981:103). Correspondingly, a study involving men and women engineering technology students concluded that women students enter the technical programs with slightly better academic records than their male counterparts (Tarmy Rudnick and Kirkpatrick, 1981).

Clearly, women engineering students have a higher rate of attrition than their academic records as well as SAT scores would predict (Baum, 1990). Similarly, the attrition rate of minority engineering students is inordinately high. Given the literature which focuses solely on women or minorities, one could conclude minority women have an even higher rate of attrition as a result of their dual statuses of race and gender.

Barriers to women and minorities in engineering programs

Numerous researchers (Adams, 1988; Asbrand, 1986; Baum, 1990; Zimmer Daniels, 1988; Forbes and Edosomwan, 1990; Fulco and Dallaire, 1973; Hoel, Francois, and Lloyd, 1243; Ivey, 1988; Meade, 1991; Russel, 1991; Skoner

and Jalongo, 1988; Stake, 1979; Tobin and Woodring, 1988) have attributed the lower retention rate of women and minority engineering students to the barriers women and minorities encounter in engineering programs. These barriers which are encompassed by the category, "systemic obstacles which constrain the retention of women and minorities in engineering," will be the focus of the following literature review. Elements to be discussed include:

- Lack of mentors and/or role models
- A sense of social isolation
- Unsupportive attitudes of advisors, parents and peers
- Lower expectations of women and minorities
- Low self-confidence

Lack of mentors and/or role models Researchers (Baum, 1990; Forbes and Edosomwan, 1990; Hoel, Francois, and Lloyd, 1234; Ivey, 1988; Meade, 1991; Tobin and Woodring, 1988) agree positive mentors and/or role models are vital in attracting and retaining women and minorities in engineering. According to Ivey, there is a direct correlation between the number of women faculty members in engineering programs and the number of women graduates who pursue careers in the engineering field (1988). In support of this finding, Ivey cites the disproportionately positive effect single-sex institutions have on the pool of women engineers (1988). Women's colleges produce four research scientists to every one produced by co-ed colleges (Meade, 1991).

A sense of social isolation According to researchers (Asbrand, 1986; Baum, 1990; Fulco and Dallaire, 1973; Hayden and Holloway, 1985; Ivey, 1988; Landis, 1988; Lantz, 1982), a student is less likely to be retained when he/she experiences a sense of gender/racial isolation. Interviews conducted by Connolly and Porter revealed that same-sex peer support is requisite for

increasing the retention rate of women (1978). Similarly, the existence of an identifiable racial group has been contributed to the success of an Engineering Opportunity Program created and designed to aid disadvantaged students (Thompson, Smithberg and Anderson, 1972).

Unsupportive attitudes of advisors, parents and peers A number of researchers (Adams, 1988; Asbrand, 1986; Baum, 1990; Zimmer Daniels, 1988; Fulco and Dallaire, 1973; Meade, 1991; Russel, 1991; Tobin and Woodring, 1988) cite the unsupportive attitudes of advisors, instructors, parents and peers as potential barriers to the retention of women and minority engineering students. According to Meade, many female students experience discriminatory attitudes in the classrooms. Male instructors, who dominate faculty positions in engineering colleges, often "defer to men and actively discourage women" students (1991:21).

Minority students encounter similar discriminatory attitudes--too often facing racial prejudices on the part of instructors, advisors and peers (Asbrand, 1986).

Additionally, Diederich Ott cites the extent to which parental opinions on college attendance influences the retention rates of women. Women who indicated their parents' opinion of college attendance was "extremely important" were more likely to be retained than women who indicated their parents were not supportive (Diederich Ott, 1978).

Lower expectations of women and minorities This barrier is closely related to unsupportive attitudes of advisors/instructors/peers, for it is, often, a reflection of the discriminatory attitudes of instructors. Within the classroom setting, instructors impose their racial and gender biases on women and

minorities. Rather than a sense of encouragement, women and minorities experience a sensation the instructor does not expect them to succeed (Ivey, 1988; Landis, 1988).

Low self-confidence According to Tobin and Woodring, the poor self-image and lowered self-confidence of minority students has contributed to their low level of representation in undergraduate engineering programs (1988). Similarly, "across a wide variety of performance settings and tasks", women have lower self-confidence and performance expectations than their male counterparts (Stake, 1979:367). This phenomenon persists even when the abilities of women equal or surpass the abilities of men (Stake, 1979). At the University of Washington, the mean grade point average of women who leave the engineering program is 3.2. Male engineering students, however, are satisfied to continue the program with B and C averages (Meade, 1991).

Attrition, barriers and minority women

It is evident from the previous discussion of attrition rates and systemic obstacles which inhibit the retention of women and minorities in engineering the literature has concentrated on women and/or minorities. By focusing on gender or race, the unique experiences of minority women have been virtually ignored. In an examination of retention rates of men and women engineering students, however, Diederich Ott does note a difference in the rate of retention of Caucasian and non-Caucasian women: No difference exists between the rate of retention of Caucasian and non-Caucasian men. Diederich Ott suggests this phenomenon has occurred due to special difficulties minority women may encounter in engineering programs (1978).

CHAPTER THREE

THEORY

Two fundamentally opposing theories have been derived as a means of explaining the inequitable educational experiences of lower-class, minority, and female students–experiences which have led to the under-representation of women, minorities and, specifically, minority women in the field of engineering.

Rooted in structural-functionalism, the **meritocratic view** postulates inequality occurs within society as a result of differences in individuals' talents or merit. Individuals are perceived to have considerable opportunity for economic mobility and are, therefore, capable of markedly altering their adult social status from that into which they were born. The educational system, according to the meritocratic view, is a primary facilitator of this upward mobility (Chesler and Cave, 1981).

The United States school system evolved from the growth of industrialization in North America and the demand for trained individuals to fill industrial positions. Consistent with the ideal of American democracy, education was perceived as a means of overcoming limitations of birth status and providing all talented individuals access to higher statused economic and social positions. Selection and training of the most talented individuals, in turn, ensured the most efficient and productive operation of the United States economic system. According to the meritocratic view, the public school system was erected to equitably nurture individuals' abilities and allocate said individuals positions consistent with their capabilities and interests (Chesler and Cave, 1981).

The **class analysis view** posits a theoretically opposing position on the inequality of schooling to that proposed by the meritocratic view. Rooted in conflict/Marxist ideology, the class analysis view emphasizes the role of political and economic structures in defining and determining an individual's place in the overall social structure. According to this view, personal achievement is, thereby, limited by the power of an individual's social environment. Included in this environment is one's economic class location--a position difficult for individuals to overcome. Individuals capable of superceding limitations of birth are the exceptions rather than the norm, for the social status of a majority of adult individuals remains consistent with that of the families into which they were born. The class analysis view perceives the public school system as a mechanism which facilitates the stabilization of the class structure by allocating positions in accordance with an individual's economic origins (Chesler and Cave, 1981).

The class analysis view asserts the United States educational system was established as a means of controlling the increasing North American population which resulted from modern industrialization. Given the influx of immigrants as well as the desire of lower statused individuals to advance their positions, a need emerged for a mechanism capable of maintaining social order and ensuring that children born into certain statuses succeeded to positions consistent with said statuses. Public schools were, therefore, established as a means of socializing and channeling people in accordance with their original and probable future social locations (Chesler and Cave, 1981).

Both views have been widely supported by sociological theorists. The meritocratic view, however, is limited by its focus on individual characteristics and disregard for wider systemic restrictions. It is for this reason, the class analysis view will be drawn upon as the basis for the following theoretical analysis.

Social reproduction

The theory of social reproduction has evolved from the class analysis view of inequality in education and exemplifies the trend of theorists toward a conflict based ideology with regard to the role of education. Pierre Bourdieu, a French sociologist, has essentially challenged the traditional meritocratic view by addressing the effect of the social structure on educational experiences, which, in turn, generates the reproduction of social inequality.

Prior to industrialization, an individual's status in society was determined by ascribed characteristics, i.e., familial, racial and/or gender attributes. With the evolution of industrialization accompanied by the growing belief in democratic principles and equality, the dominant group could no longer overtly grant status based solely on ascriptive attributes. Rather, a more discreet and legitimate method of social control had to be instituted. Bourdieu asserts the system of higher education was erected as a means of assuming the mission of the dominant class in preserving elite interests while simultaneously sustaining the appearance of a democratic/meritocratic ideology (Swartz, 1977).

According to the theory of social reproduction, the educational system distributes cultural capital akin to that transmitted by the dominant culture.

An individual's academic success is, therefore, dependent upon his/her previous familiarity with the dominant culture--an experience which is inequitably sustained by individuals of different social classes. Although the system of education is explicitly entrusted with the function of transmitting the instruments for all individuals to achieve elite status, it implicitly provides the information and training needed for success only to those individuals familiar with the instruments of appropriation. The dominant culture is, thereby, perpetuated through the educational system (Bourdieu, 1973 in Karabel and Halsey, 1977).

In addition to reproducing the dominant culture, education assists in the maintenance of the existing social structure by socializing individuals into relatively stable cultural dispositions. These dispositions are, ultimately, internalized and aid in the acceptance of the social order by subordinate groups. According to Bourdieu, subjective hopes are closely correlated to objective chances with objective chances mediating an individuals attitudes, behaviors, and, inevitably, his/her hopes. The role of the educational system in influencing an individual's academic expectations is, thereby, emphasized in social reproduction theory (Swartz, 1977).

The under-representation of non-traditional students is also addressed by social reproduction theory. As individuals traverse the educational pipeline, the restriction of the educational system on members of subordinate classes intensifies. This phenomenon is largely a result of the reinforcement of the dominant class culture on the part of learning institutions which, thereby, functions as a segregating and, inevitably, suppressing mechanism

on individuals from subordinate class cultures (Bourdieu, 1973 in Karabel and Halsey, 1977).

It is important to note, Bourdieu's argument is not one of simple class determinism. Rather, he envisions the educational system as being "relatively autonomous" in relation to external structures. An individual's social class background is, therefore, determined through the interactions of a complex set of factors which interact in varying ways at the different levels of education (Swartz, 1977).

One of the major limitations of Bourdieu's argument is his reliance on Marx's narrow definition of dominant culture, i.e., he equates dominant culture with social class. Within the United States, the fundamental basis for stratification is social class, i.e., whether an individual is a member of the upper, middle or lower class. Although this may be the primary level of stratification, it is not singular. Applying Weberian theory, outside factors, such as race and gender, have developed a caste-like structure, transforming racially segregated/gender groups into a vertical social system of super- and subordination. When the latter level of stratification is superimposed upon the former, inequities created by the initial level of stratification are intensified (Weber, 1946). Clearly, issues of race and gender must be addressed when speaking in terms of "dominant culture".

Social reproduction–an application

Within the field of engineering, the dominant class is comprised of Caucasian men. Characteristics of this dominant culture include:

- Bias in standardized testing
- Placement in college-bound as opposed to non-college bound tracks
- Possession of the requisite language/vocabulary skills
- Increased participation in pre-college science and math courses
- Active encouragement on the part of guidance ounselors
- Strong family values with regard to schooling
- Adequate financial assistance
- A generous supply of mentors and/or role models
- Being surrounded by a group of peers similar to oneself
- Supportive attitudes of advisors, teachers, parents and peers
- High expectations by teachers
- High levels of self-confidence

A student's familiarity with these objective mechanisms of the dominant class ultimately determines his/her success in the engineering program. Although the educational system is explicitly entrusted with the task of transmitting these mechanisms for attaining the degree, it is, implicitly, biased in favor of the dominant class, i.e., white men. For non-traditional engineering students, i.e., women and minorities, the objective mechanisms of the dominant class become barriers to the completion of their programs of study. As women and minorities traverse the educational pipeline, said barriers are internalized and inevitably serve to socialize these groups into more traditional fields of study. As a result, the number of non-traditional students who actually obtain engineering degrees is limited: the monopolistic strong-hold of white males on the engineering profession is, thereby, preserved.

The situation of women and minorities in the engineering profession should not, however, appear completely bleak. The fact that an increasing number of women and minority students are earning degrees in engineering is evidence of the autonomous nature of the educational system in relation to external structures, i.e., structures outside the educational system such as the family unit and the public and private business sectors. Intervention

programs on behalf of women and minority science and engineering students, for example, are becoming more and more widespread. In addition, women and minorities are playing an ever expanding role in the public and private sectors. These external factors interact in various ways at the different levels of schooling and, thereby, mediate the career paths individuals choose to pursue. Increased exposure to such external factors can serve only to familiarize women and minorities with the mechanisms of the dominant culture and, ultimately, increase the number of Caucasian women, minority men, and minority women engineering professionals.

CHAPTER FOUR

METHODOLOGY

Sample Selection Procedures

Names and addresses of 750 women and minority undergraduate engineering students from Iowa State University and the University of Iowa were obtained for the study. On the University of Iowa campus, every woman in all departments of the engineering college was contacted (N = 231): all minority men from the four protected classes, i.e., African-American, Native-American, Hispanic-American, and Asian-American, in all departments of the engineering college, who are citizens of the United States were included in the study (N = 72). With regard to subjects on the Iowa State campus, all women in all departments of the engineering college, who are United States citizens were recruited for the study (N = 346): all minority men, from the four protected classes, i.e., African-American, Native-American, Hispanic-American, and Asian-American, in all departments of the engineering college, who are citizens of the United States were contacted (N = 101).

Since Pierre Bourdieu's social reproduction theory is based on modern industrialized societies, it is necessary to use subjects who have traversed an educational pipeline consistent with that of a capitalistic system. It is for this reason, only the responses of United States citizens are utilized in the final analysis.

Questionnaires were mailed to each of the 750 undergraduate engineering students selected for this research (See Appendix A). Due to regulations with regard to recruitment of subjects on the University of Iowa campus, only a single wave of questionnaires was distributed. Prior to its

distribution on the Iowa State and University of Iowa campuses, the survey instrument was approved by the Iowa State University Human Subjects Review Committee and the University of Iowa Committee D.

Of the 750 questionnaires distributed, 334 eligible responses were returned for a response rate of approximately 45 percent. It is important to note, once again, the final sample of 334 includes only United States citizens. "United States citizen" was not a requirement in the recruitment of women on the University of Iowa campus; therefore, the final response rate of 45 percent is somewhat distorted.

For the total sample of 334 individuals, approximately 86 percent (287) are Caucasian and minority women, the other 14 percent (45) are minority men. Of the 287 women in the sample, 90 percent (258) are Caucasian and 10 percent (29) are minority. Table 4.1 illustrates the racial breakdowns of minority women and minority men in the sample.

As of spring semester, 1992, 13 percent of the individuals surveyed said they were freshmen, 26 percent classified themselves as sophomores, 26 percent said they were juniors, and 34 percent identified themselves as seniors. All departments of the engineering colleges on both the University of Iowa and Iowa State campuses were represented by the sample. The distribution of subjects by academic major is broken down in Table 4.2.

Analysis procedures

Respondents were requested to indicate their perceptions on the extent to which women and minorities experience 13 designated "barriers", i.e., factors allegedly contributing to the low number of women and minorities in the field of engineering. In addition, respondents were asked whether these barriers

Table 4.1 Racial breakdowns of minority men and women undergraduate engineering respondents

Racial Classification	Men	Women
Native American		
N	----	6
Percent	----	(21)
African American		
N	9	6
Percent	(20)	(21)
Hispanic American		
N	12	4
Percent	(27)	(14)
Asian American		
N	24	13
Percent	(53)	(44)
Total N	45	29

Table 4.2 Distribution of subjects by academic major

Engineering department	Percent
Industrial	17
Chemical	16
Mechanical	15
Civil	13
Electrical	11
Biomedical	7
Civil/Environmental	5
Aerospace	3
Computer	2
Construction	2
Other	9

had been problematic for them in their engineering programs. These barriers include:

- Lack of encouragement from teachers or counselors
- Limited information about possible jobs and training opportunities
- Lack of encouragement from family and friends
- Lack of confidence in ability to handle the work
- Lack of contact with women/minorities in the engineering field
- Limited opportunities for teaching and research assistantships
- Competitive atmosphere in engineering classes
- Discriminatory attitudes toward women/minorities on part of faculty or others in engineering classes
- Limited opportunities to join informal study and/or social support groups with other students
- Limited mentoring experiences
- Limited opportunities to participate in informal groups with professors
- Inadequate academic advising and/or career counseling
- Limited opportunities for meaningful internships in the field

Based on the questionnaire responses, factor analysis, varimax rotation and reliability tests were conducted to determine the relationships among the different variables. Factor analysis is a data reduction technique whereby many variables are condensed into a few underlying constructs (Hedderson, 1987). As a means of more clearly illustrating the relationships among the variables, a varimax rotation is conducted to "maximize the tendency of each variable to load highly on only one factor" (Hedderson, 1987:164). Variables with a factor score of 0.40 or greater are said to be defined by the factor. Those variables that are similarly defined during the varimax rotation are, then, grouped into scales. Based on the factors produced by the factor analysis and varimax rotation, reliability tests are conducted. Scales producing high alpha coefficients are evidence that the scale, when applied repeatedly to the same object, will yield the same results each time (Babbie, 1989).

From these analyses, i.e., the factor analysis, varimax rotation and reliability tests (See Appendix B and Appendix C), it was concluded the thirteen variables could be condensed into three different scales. One variable, however, failed to "fit" with any of the aforementioned scales. It, therefore, will be analyzed independently.

Measures: Hypothesis 1

The following independent and dependent variables will be used in the analysis of the first hypothesis:

> Minority women experience "systemic barriers to retention" to a significantly greater extent than do white women or minority men

Independent variables Predictor variables in the study include two basic domains of measurement–gender and racial background. In the examination of the relationship between minority and Caucasian women's responses, the independent variable "women" will be used. This variable focuses specifically on the responses of women broken down by race. Similarly, the independent variable "minority" will be utilized in the examination of the relationship between responses of minority men and women. This variable focuses solely on the responses of minorities broken down by gender.

Dependent variables As previously mentioned, three primary scales will be used:

- Personal ability to deal with the program
- Sense of support from outside sources
- Sense of belonging

Personal ability to deal with the program The personal ability to deal with the program scale consists of three barriers:

- Lack of confidence in ability to handle the work
- Lack of contact with women/minorities in the engineering field
- Competitive atmosphere in engineering classes

Respondents were requested to indicate their perceptions on the extent to which these three barriers have contributed to the under-representation of women or minorities in the field of engineering. Answers on each item ranged from 1 to 3, with 1 signifying the barrier has contributed to "none" of the under-representation and 3 signifying the barrier has contributed to "a lot" of the under-representation. The scores for each of the three barriers were summed and divided by 3 to obtain a mean score for the scale. The scale score, which ranges from 3 to 9, addresses respondents' perceptions on the extent to which individuals' personal capabilities to deal with engineering programs have contributed to the under-representation of women/minorities in the engineering field. In addition to their perceptions, respondents were asked to indicate whether the three barriers have been problematic for them personally, with 1 indicating a "no" response and 2 indicating a "yes" response. Based on subjects' responses with regard to their personal experiences, the scores for the three barriers were summed and divided by 3 to obtain a mean scale score. This scale score, which ranges from 3 to 6, addresses the extent to which respondents have found their personal ability to deal with the engineering program to be problematic. Alpha for the personal ability to deal with the program scale equals 0.4264.

Sense of support from outside sources Five barriers constitute the scale, sense of support from outside sources. These barriers include:

- Inadequate academic advising and/or career counseling
- Limited opportunities for meaningful internships in the field
- Limited information about possible jobs and training opportunities
- Lack of encouragement from family and friends
- Lack of encouragement from teachers or counselors

Respondents' answers to these five barriers were used to assess the extent to which subjects perceive the under-representation of women and minorities in engineering is related to support from outside sources. Responses for each barrier ranged from 1 to 3, with 1 representing a "none" response, 2 representing a "some" response and 3 representing an "a lot" response. To determine a mean scale score that measures respondents' perceptions, answers to the five barriers were summed and divided by 5. This scale score ranges from 5 to 15. Respondents additionally were requested to indicate whether support from outside sources was a problem for them personally, with a 1 indicating a "no" response and a 2 indicating a "yes" response. A mean scale score for respondents' personal experiences was derived by summing responses to the five barriers and dividing by 5. This scale score ranges from 5 to 10. Alpha for the sense of support from outside sources scale equals 0.5529.

Sense of belonging The sense of belonging scale consists of four barriers:

- Limited mentoring experiences
- Limited opportunities to participate in informal groups with professors
- Limited opportunities to join informal study and/or social support groups with other students
- Limited opportunities for teaching and research assistantships

Respondents were requested to indicate the extent to which these four barriers have contributed to the under-representation of women or minorities in the field of engineering. A 1 response indicates the respondent considers the four barriers to have contributed to "none" of the under-representation: A 3 response indicates the respondent considers the four barriers to have contributed to "a lot" of the under-representation. The scores for each of the four barriers were summed and divided by 4 to obtain a mean score for the scale. This scale score, which ranges from 4 to 12, addresses respondents' perceptions on the extent to which individuals' sense of belonging has contributed to the under-representation of women/minorities in the engineering field. Similarly, individuals were asked whether the four barriers were problematic for them personally, with 1 signifying a "no" response and 2 signifying a "yes" response. Based on subjects' responses with regard to their personal experiences, the scores for the four barriers were summed and divided by 4 to obtain a mean score for the scale. This scale score, which ranges from 4 to 8, addresses the extent to which respondents have found a sense of belonging to be problematic. Alpha for the sense of belonging scale equals 0.5943.

Discriminatory attitudes on part of faculty/others As previously mentioned, one single barrier failed to fit with any of the scales. The variable pertains to discriminatory attitudes toward women/minorities on the part of faculty or others in engineering classes. Respondents were questioned about the extent to which this variable contributes to the low number of women or minorities in engineering fields. A 1 response signifies the respondent considers "none" of the under-representation of women and minorities to be

attributed to discriminatory attitudes; whereas, a 3 signifies the respondent considers "a lot" of the under-representation to be attributed to discriminatory attitudes. Correspondingly, individuals were questioned with regard to their own personal exposure to discriminatory attitudes. A 1 indicates a "no" response: A 2 indicates a "yes" response.

Measures: Hypothesis 2

The following independent and dependent variables will be used in the analysis of the second hypothesis:

> There is a greater potential for attrition among minority women because they experience "systemic barriers to retention" to a greater extent than do white women and minority men

Independent variables To analyze the second hypothesis, the three scales and the barrier pertaining to discrimination will act as predictor variables for this analysis. In addition, "women" will act as the control variable in the analysis of the relationship between Caucasian and minority women, and "minority" will act as the control variable in the analysis of the relationship between minority men and women.

Dependent variable Respondents were asked whether they had considered leaving the engineering program at their current university. A 1 response indicates the individual "very seriously" contemplated leaving the program; whereas, a 3 response indicates the individual has not considered leaving.

Content analysis

Content analysis is "any technique for making inferences by systematic and objective identifying special characteristics of messages" (Holsti, 1968:608 in Berg, 1989:106). In an attempt to expand on the quantitative portion of the questionnaire, respondents were asked to answer a single open-ended question: "As an engineering student, have you had any uncomfortable experiences in your academic program?" Content analysis of the responses given to this question by minority women will be conducted. To establish a means of comparison, the responses of minority men will also be examined. The results of these analyses will be discussed in the next chapter.

CHAPTER FIVE

RESULTS

Data analysis–Hypothesis 1

Analysis of the first hypothesis:

> Minority women experience "systemic barriers to retention" to a significantly greater extent than do white women or minority men

was conducted using the "means" and "crosstabs" commands of SPSS for Windows statistical program. In order to lend support for the hypothesis, there should be a marked relationship between each of the three barrier scales and the perceptions/experiences of the respondents. Additionally, a significant relationship should exist between the individual discrimination variable and the perceptions/experiences of the respondents. These relationships should be more significant for minority women than for Caucasian women or minority men.

Differences between minority and Caucasian women's perceptions: Scales To determine the differences between minority women's and Caucasian women's perceptions of the extent to which barriers contribute to the low number of women in engineering, analysis of variance tests were conducted based on the responses of minority and Caucasian women for each of the three scales. Table 5.1 presents the results. As the table indicates, differences between the responses have been assessed according to five criteria: Mean, F-test, Between Group Significance, Eta and Eta-squared.

Table 5.1 Minority and Caucasian women engineering student's perceptions of the extent to which barriers contribute to the low numbers of women in engineering.

Dependant Variables	Minority women Mean	White women Mean	F-test	Between Group Significance	Eta	Eta-squared
Personal ability to deal with program	7.03[1]	6.88[1]	.318	.574	.034	.001
Support from outside sources	10.29[2]	10.36[2]	.031	.861	.011	.000
Sense of belonging	7.21[3]	6.90[3]	.648	.421	.050	.003

1 Mean ranges from 3 to 9
2 Mean ranges from 5 to 15
3 Mean ranges from 4 to 12

The higher the mean score for each scale, the greater the extent that individuals perceive the scales to contribute to the under-representation of women in engineering (according to the perceptions of women respondents).

As can be seen from Table 5.1, the mean scores indicate perceptions of minority women and Caucasian women are fairly close. For both groups, the mean scale score is slightly greater than the median for the "personal ability to deal with the program" scale and the "support from outside sources" scale but is slightly less than the median for the "sense of belonging" scale.

Relatively large values of the F-test statistic represent strong evidence against the null hypothesis, i.e., that the mean scores for the two groups do not differ significantly. To reject the null hypothesis, the F-score should exceed the critical F-value of 3.89 (the critical value is based on degrees of freedom of 1 and 270, and alpha of .05). From Table 5.1, it is evident none of the F-scores for each of the barrier measures exceeds 3.89: The F-tests are not significant. The mean scores for the perceptions of minority women, therefore, do not differ significantly from the mean scores for the perceptions of Caucasian women.

Statistical significance is the probability that differences in the means are due to sampling error. Table 5.1 presents the Between Group Significance for minority and Caucasian women based on each of the barrier scales. Clearly, none of the between group differences are statistically significant, suggesting the possibility that the differences in means for each of the measures are due to sampling error.

Ranging in value from 0 to 1.0, eta measures the strength of the correlation between the independent variable "women" and each of the three dependent scales. As a general rule, a value of 0.30 or less represents a weak

relationship; a value between 0.30 and 0.70 represents a moderate relationship; and a value of 0.70 or above represents a strong relationship. From Table 5.1, it is evident there is virtually no relationship between "women" and each of the three barrier scales.

Eta-squared indicates the proportion of variance in each of the scales that is explained by "women" or the proportionate reduction in error in predicting how individuals will respond to each of the scales given knowledge of their gender and racial background. Clearly, from Table 5.1, all of the eta-squared values for each of the measures are around 0.00. This can be interpreted as saying that almost zero percent of the variance in each of the barrier scales can be explained by "women," or knowledge of an individual's gender and racial background reduces approximately zero percent of the error in predicting responses to each of the barrier scales.

Differences between minority and Caucasian women's perceptions: Individual Discrimination Variable To determine the differences between minority women's and Caucasian women's perceptions of the extent to which the individual discrimination variable contributes to the low number of women in engineering, cross-tabulations and chi-squared tests were conducted. Table 5.2 presents the results. As the table illustrates, both groups' perceptions were comparable, with 28% of minority women and 29% of white women believing discriminatory attitudes contribute "a lot" to the low number of women in engineering, and 45% of minority women and 50% of white women believing discriminatory attitudes contribute "some" to the under-representation of women. Interestingly, slightly more minority women than white women (28%

Table 5.2 **Minority and Caucasian women engineering student's perceptions of the extent to which discriminatory attitudes on the part of faculty and others contribute to the low numbers of women in engineering.**

	Minority women (n=29) Percentage	White women (n=243) Percentage
None	28%	21%
n=	8	51
Some	45%	50%
n=	13	122
A lot	28%	29%
n=	8	70

Chi-squared	.772
Between Group Significance	.680

as opposed to 21%) indicated the perception that discriminatory attitudes do not contribute to the low number of women in engineering.

Differences between minority men's and women's perceptions: Scales

To determine the differences between minority men's and minority women's perceptions of the extent to which barriers contribute to the low number of minorities in engineering, analysis of variance tests were again conducted, this time based on the responses of minority men and women for each of the scale measures. The results are presented in Table 5.3. Differences between responses have been assessed according to Mean, F-test, Between Group Significance, Eta and Eta-squared.

The higher the mean score for each scale, the greater minorities perceive the scales to contribute to the under-representation of minorities in engineering. As Table 5.3 indicates, minority women consistently rate the scales higher than minority men. For minority women, the mean score on all three scales is greater than their respective medians: For minority men, the mean score exceeds the median only for the "personal ability to deal with the program" scale.

Differences between minority men's and women's perceptions: Individual Discrimination Variable To determine the differences between minority men's and minority women's perceptions of the extent to which discriminatory attitudes contribute to the low number of minorities in engineering, cross-tabulations and chi-squared tests were conducted based on the responses of minority men and women to the individual discrimination variable. The results are presented in Table 5.4.

Table 5.3 Minority men and women engineering student's perceptions of the extent to which barriers contribute to the low numbers of minorities in engineering.

Dependant Variables	Minority men Mean	Minority women Mean	F-test	Between Group Significance	Eta	Eta-squared
Personal ability to deal with program	6.79[1]	7.39[1]	.877	.352	.112	.013
Support from outside sources	9.86[2]	10.57[2]	2.381	.127	.181	.033
Sense of belonging	7.65[3]	8.36[3]	.920	.341	.115	.013

1 Mean ranges from 3 to 9
2 Mean ranges from 5 to 15
3 Mean ranges from 4 to 12

Table 5.4 **Minority men and women engineering student's perceptions of the extent to which discriminatory attitudes on the part of faculty and others contribute to the low numbers of minorities in engineering.**

	Minority men (n=44) Percentage	Minority women (n=28) Percentage
None	23%	25%
n=	10	7
Some	59%	43%
n=	26	12
A lot	18%	32%
n=	8	9

Chi-squared	2.304
Between Group Significance	.316

As the table illustrates, a considerably larger percentage of minority women than minority men perceived that discriminatory attitudes contribute "a lot" to the underrepresentation of minorities in engineering. Although the differences in the perceptions of minority men and women are not statistically significant, the differences in their perceptions are notably greater than the differences in the perceptions of minority and white women.

Differences between Caucasian and minority women's experiences: Scales The differences between Caucasian and minority women's experiences in their engineering programs are presented in Table 5.5. Analysis of variance tests were conducted based on the responses of Caucasian and minority women for each of the three scales. As the table indicates, differences between the responses have been assessed according to the five criteria: Mean, F-test, Between Group Significance, Eta and Eta-squared.

The higher the mean score for the scales the greater the scale was considered to be a problem. As Table 5.5 indicates, the experiences of minority and Caucasian women are fairly close. Although the mean scores for minority women are higher than the mean scores for Caucasian women for the "personal ability to deal with the program" scale and the "sense of belonging" scale, the mean score for minority women on the "personal ability to deal with the program" scale is the only value to exceed its respective median.

To reject the null hypothesis, i.e., the mean scores for the two groups do not differ significantly, the F-score should exceed the critical F-value of 3.89 (based on degrees of freedom of 1 and approximately 269, and alpha of .05). It is evident from Table 5.5, one of the scales, the "sense of belonging scale"

Table 5.5 The extent to which minority v. Caucasian women have experienced barriers in their engineering programs

Dependant Variables	Minority women Mean	White women Mean	F-test	Between Group Significance	Eta	Eta-squared
Personal ability to deal with program	4.54[1]	4.37[1]	.509	.476	.043	.002
Support from outside sources	6.64[2]	6.65[2]	.001	.982	.001	.000
Sense of belonging	5.57[3]	4.95[3]	7.590	.006*	.170	.030

1 Mean ranges from 3 to 6
2 Mean ranges from 5 to 10
3 Mean ranges from 4 to 8
* Significant difference at .01 level

exceeds the critical value. In this instance the null hypothesis, therefore, can be rejected. This indicates minority women have encountered in their programs of study problems with a sense of belonging to a more significant degree than have Caucasian women. Once again, although this difference is significant, the scale score for minority women does not exceed its respective median.

The Between Group Significance for minority and Caucasian women based on each of the barrier scales is presented in Table 5.5. For the "sense of belonging scale," the significance is acceptable at the .01 level.

Differences between Caucasian and minority women's experiences: Individual Discrimination Variable The differences between Caucasian and minority women's experiences with discriminatory attitudes in their engineering programs are presented in Table 5.6. Cross-tabulations and chi-squared tests were conducted based on the responses of Caucasian and minority women to the individual discrimination variable.

As the table illustrates, although not to a statistically significant degree, a larger percentage of minority women than white women reported having experienced discriminatory attitudes on the part of faculty and others in their engineering programs.

Differences between minority men's and women's experiences: Scales To determine the differences between the experiences of minority men and women in their programs of study, analysis of variance tests were conducted based on the responses of minority men and women for each of the scale measures. Table 5.7 presents the results. Differences among responses have

Table 5.6 The extent to which minority v. Caucasian women have experienced discriminatory attitudes in their engineering programs

	Minority women (n=28) Percentage	White women (n=244) Percentage
No	45%	59%
n=	13	144
Yes	52%	40%
n=	15	98
Chi-squared	2.325	
Between Group Significance	.313	

Table 5.7 The extent to which minority men v. minority women have experienced barriers in their engineering programs

Dependant Variables	Minority men Mean	Minority women Mean	F-test	Between Group Significance	Eta	Eta-squared
Personal ability to deal with program	4.07[1]	4.54[1]	3.267	.075	.213	.045
Support from outside sources	6.50[2]	6.64[2]	.175	.677	.051	.003
Sense of belonging	5.32[3]	5.57[3]	.634	.429	.097	.009

1 Mean ranges from 3 to 6
2 Mean ranges from 5 to 10
3 Mean ranges from 4 to 8

been assessed according to Mean, F-test, Between Group Significance, Eta and Eta-squared.

The higher the mean score for each scale, the greater the scale is considered to be a problem. As can be seen from Table 5.7, the mean scores for each of the barrier scales are higher for minority women than for minority men, although the only score that exceeds its respective median is that for the "personal ability to deal with the program" scale.

Differences between minority men's and women's experiences: Individual Discrimination Variable To determine the extent to which minority men versus minority women experience discriminatory attitudes in their programs of study, cross-tabulations and chi-squared tests were conducted based on the responses of minority men and women to the individual discrimination variable. Table 5.8 presents the results.

As the table illustrates, although not statistically significant, a notably larger percentage of minority women than minority men (52% as opposed to 27%) reported having experienced discriminatory attitudes in their engineering programs.

Data analysis--Hypothesis 2

Analysis of the second hypothesis:

> There is a greater potential for attrition among minority women because they experience "systemic barriers to retention" to a greater extent than do white women and minority males.

was conducted using the "means" and "crosstabs" commands of SPSS for Windows statistical program. In order to lend support for the hypothesis,

Table 5.8 The extent to which minority men v. minority women have experienced discriminatory attitudes in their engineering programs

	Minority men (n=43) Percentage	Minority women (n=28) Percentage
No	67%	45%
n=	29	13
Yes	27%	52%
n=	12	15

Chi-squared	4.820
Between Group Significance	.090

individuals who experience the barriers to a greater extent should have an increased likelihood to consider leaving their engineering program.

Effect of barriers on Caucasian and minority women's consideration to leave program: Scales To determine the extent to which problems with barriers in their engineering programs have influenced minority and Caucasian women's contemplation of leaving their programs of study, analysis of variance and chi-squared tests were conducted based on the scale scores of each group for each of the three barrier scales and a question pertaining to how seriously they may have considered leaving their program of study. Table 5.9 presents the results.

As the table illustrates, for all women, both minority and white, on all three scales, the strength of which respondents with scale scores greater than each scale's respective median have contemplated leaving their programs of study differs significantly from the strength of which respondents with scale scores less than each scale's respective median have contemplated leaving. In other words, women with scale scores greater than the median are more likely to consider leaving their programs of study than women with scale scores less than the median. Data indicate this result additionally is true for white women.

Significant differences were not found on any of the three scales between the group of minority women with scale scores higher than the median and the group of minority women with scale scores lower than the median. Of the three scales, however, data suggest minority women's contemplation of leaving their programs of study is most heavily impacted by their personal ability to deal with the program.

Table 5.9 The extent to which barrier scales contribute to minority and Caucasian women's contemplation of leaving their engineering program

Independent Variables	Minority women: Very Seriously Considered	Minority women: Somewhat Seriously Considered	Minority women: Have Not Considered	White women: Very Seriously Considered	White women: Somewhat Seriously Considered	White women: Have Not Considered	All women[1]: Between Group Significance
Personal ability to deal with program							
≤ Median	(n=16) 13%	19%	69%	(n=133) 10%	27%	71%	
> Median	(n=12) 8%	67%	25%	(n=108) 19%	45%	35%	
Between Group Significance		.274			.000*		.000*
Support from outside sources							
≤ Median	(n=22) 14%	36%	50%	(n=174) 13%	30%	60%	
> Median	(n=6) 0%	50%	50%	(n=67) 18%	46%	36%	
Between Group Significance		.372			.009*		.001*
Sense of belonging							
≤ Median	(n=20) 15%	35%	50%	(n=204) 14%	30%	55%	
> Median	(n=8) 0%	50%	50%	(n=24) 21%	58%	21%	
Between Group Significance		.776			.001*		.007*

1 Score represents the difference between "≤ median" and "> median" scale scores for all women, both minority and white

* Significant difference at .01 level

Effect of barriers on Caucasian and minority women's consideration to leave program: Individual Discrimination Variable To determine the extent to which discriminatory attitudes have influenced minority and Caucasian women's contemplation of leaving their engineering programs, chi-squared tests were conducted based on minority and white women's experiences with discriminatory attitudes and the question assessing how seriously respondents have contemplated leaving their programs of study. The results are presented in Table 5.10.

As the table illustrates, although the differences are not statistically significant, a larger percentage of both minority and white women who have experienced discriminatory attitudes have contemplated leaving their programs of study.

Effect of barriers on minority men and women's consideration to leave program: Scales To determine the extent to which problems with barriers in their engineering programs have influenced minority men's and women's decisions to leave their programs of study, analysis of variance and chi-squared tests were conducted based on the scale scores of each group for each of the three barrier scales. The results are presented in Tables 5.11.

As the table illustrates, there were no significant differences on any of the three scales between the group of minority men with scale scores greater than the median and the group of minority men with scale scores less than the median. In other words, minority men with scale scores greater than the median are not necessarily more likely to consider leaving their programs of study than minority men with scale scores less than the median. Data indicate this result additionally is true for minority women.

Table 5.10 The extent to which discriminatory attitudes contribute to minority and Caucasian women's contemplation of leaving their engineering program

Independent Variables		Minority women: Very Seriously Considered	Minority women: Somewhat Seriously Considered	Minority women: Have Not Considered		White women: Very Seriously Considered	White women: Somewhat Seriously Considered	White women: Have Not Considered
Discriminatory attitudes on the part of faculty and others								
Yes	(n=15)	13%	47%	40%	(n=98)	15%	42%	43%
No	(n=13)	8%	31%	62%	(n=145)	13%	30%	57%
Between Group Significance			.596				.238	

Table 5.11 The extent to which barrier scales contribute to minority men and minority women's contemplation of leaving their engineering program

Independent Variables	Minority men: Very Seriously Considered	Minority men: Somewhat Seriously Considered	Minority men: Have Not Considered	Minority women: Very Seriously Considered	Minority women: Somewhat Seriously Considered	Minority women: Have Not Considered	All minorities[1]: Between Group Significance
Personal ability to deal with program							
≤ Median	(n=29) 14%	28%	59%	(n=12) 13%	19%	69%	
> Median	(n=14) 21%	29%	50%	(n=16) 8%	67%	25%	
Between Group Significance		.303			.274		.102
Support from outside sources							
≤ Median	(n=31) 6%	29%	45%	(n=22) 14%	36%	50%	
> Median	(n=11) 36%	9%	55%	(n=6) 0%	50%	50%	
Between Group Significance		.353			.372		.872
Sense of belonging							
≤ Median	(n=32) 13%	31%	56%	(n=20) 15%	35%	50%	
> Median	(n=9) 22%	22%	56%	(n=8) 0%	50%	50%	
Between Group Significance		.528			.776		.412

1 Score represents the difference between "≤ median" and "> median" scale scores for all minorities, both men and women

Effect of barriers on minority men and women's consideration to leave program: Individual Discrimination Variable To determine the extent to which discriminatory attitudes have influenced minority men and minority women's contemplation of leaving their engineering programs, chi-squared tests were conducted based on minority men and women's experiences with discriminatory attitudes and the question assessing how seriously respondents have contemplated leaving their programs of study. The results are presented in Table 5.12.

As the table illustrates, although the differences are not statistically significant, a larger percentage of both minority men and women who have experienced discriminatory attitudes have contemplated leaving their programs of study. The percentage, however, is higher for minority women.

Content analysis

Respondents were requested to answer one open-ended question pertaining to any uncomfortable experience/s they may have encountered in their engineering programs. The content of the responses of minority women and minority men was examined to ascertain whether minority women are experiencing barriers in ways the quantitative data fail to indicate.

Each of the responses was analyzed according to a specific and consistent set of questions:

- Did the respondent encounter an uncomfortable experience?
- Did the encounter pertain to any of the barriers included in the quantitative data analysis?
- To which barrier/s did the encounter pertain?
- Did the message imply any association with gender, race or both?

Table 5.12 The extent to which discriminatory attitudes contribute to minority men and minority women's contemplation of leaving their engineering program

Independent Variables		Minority men: Very Seriously Considered	Minority men: Somewhat Seriously Considered	Minority men: Have Not Considered	Minority women: Very Seriously Considered	Minority women: Somewhat Seriously Considered	Minority women: Have Not Considered
Discriminatory attitudes on the part of faculty and others							
Yes	(n=12)	25%	25%	50%	(n=15) 13%	47%	40%
No	(n=30)	10%	30%	60%	(n=13) 8%	31%	62%
Between Group Significance			.273			.596	

Based on these criteria, the responses were coded and tabulated accordingly. For instance, all minority men and women were initially assessed according to the first criterion: Did the respondent encounter an uncomfortable experience? All "yes" responses were then assessed according to the second criterion: Did the encounter pertain to any of the barriers included in the quantitative data analysis? If the encounter pertained to any of the barriers, the message was then assessed according to the third criterion: To which barrier/s did the encounter pertain? Based on this evaluation, the frequency distribution of messages for each of the barriers was determined. Totals for the barriers were then grouped in accordance with the three previously established scales. The frequencies for the three barriers that constitute the Personal ability to deal with the program scale were summed; the frequencies for the five barriers that constitute the Support from outside sources scale were summed; and the frequencies for the four barriers that constitute the Sense of belonging scale were summed. Finally, messages that pertained to one or more of the thirteen barriers were assessed according to the fourth criterion: Did the message indicate any association with gender, race, or both? Once again, the frequencies for each of the categories, gender, race, or both, were determined. The final results of the content analysis are as follows.

Of the 29 minority women respondents, 41 percent indicated having experienced an uncomfortable encounter within their program of study. Similarly, 37 percent of the minority men testified to having an uncomfortable experience. Of all the respondents indicating an uneasy experience, 86 percent of the encounters pertained to one or more of the three scales, i.e., the personal ability to deal with the program scale; the sense of support from

outside sources scale; and/or the sense of belonging scale, and/or the independent test variable, i.e., discriminatory attitudes toward women/minorities on the part of faculty or others in engineering classes.

The content analysis suggests there is a difference in the type of barriers minority women and minority men encounter. With regard to the scales, personal ability to deal with the program and support from outside sources, there is a minimal distinction between the experiences of minority women and men: 25 percent of women and 29 percent of men encountered the former barrier scale; likewise, 25 percent of women and 29 percent of men experienced the latter. Concerning the third, sense of belonging scale, however, 33 percent of the women as opposed to 18 percent of the men encountered this barrier scale. Specific comments made by minority women include:

- "Too few women in classes made it hard to join study groups."
- "All male professors; textbooks and films with 'he' throughout."
- "In my freshman and sophomore classes, I often felt that because I was a woman that I didn't belong there."

Similarly, 58 percent of the women, as opposed to 18 percent of the men, indicated they had encountered discriminatory attitudes on the part of faculty or others in engineering classes. Some comments expressed by minority women, include:

- "As a transfer student, when telling my academic advisor I was uncomfortable about taking physics immediately since it was my worst science class in high school (I got a B), he asked if I'd transferred to Iowa to follow a boyfriend."
- "Professors not believing you are competent–embarrass you, make you feel stupid in class. Also, a professor made a pass at me."
- "I've encountered sexist and racist teachers who don't come out straight with their feelings. It's always the subtle things."

With respect to the messages' indication of any association with gender, race, or both, it would appear the experiences of minority women are more closely linked with gender than any other classification: 50 percent of the experiences of minority women were solely gender related; 33 percent had no relation to gender or racial background; 8 percent were associated with both gender and race; and 8 percent of the experiences were solely race related. In terms of the racial background associations and the experiences of minority men, 41 percent were related to racial background; whereas, 59 percent had no relation.

CHAPTER SIX

CONCLUSIONS

Although the total number of engineering baccalaureates awarded to women and minorities has been rising, both groups remain severely under-represented in all engineering disciplines relative to the numbers of women and minorities in the United States workforce. At the college-level, researchers allege this phenomenon has occurred due to numerous barriers women and minority undergraduate engineering students encounter in their programs of study. These barriers are encompassed in the category "systemic obstacles which constrain the retention of women and minorities in engineering." Pierre Bourdieu, a French sociologist, argues the barriers are mechanisms used by educational systems to promote and socially reproduce the interests of the dominant class. As a result, women and minorities enter their engineering programs unfamiliar with the culture of the dominant class and with an inequitable ability to meet the dominant criteria required for success in a white male dominated culture.

Researchers' failure to acknowledge the unique situation of minority women sparked the primary focus of this thesis. Because minority women sustain attributes of both race and gender, it was hypothesized this group would experience "systemic barriers to retention" to a more significant degree than would white women and minority men. It was further hypothesized, this phenomenon would contribute to a greater potential for attrition among minority women.

To examine the hypotheses, all women and minority undergraduate engineering students on both the University of Iowa and Iowa State University campuses were included in a survey.

Findings

Data indicate there is marginal support for the first hypothesis:

> Minority women experience "systematic barriers to retention" to a significantly greater extent than do white women and minority men.

With regard to the differences between minority and Caucasian women's perceptions of the extent to which barrier scales contribute to the low numbers of women in engineering, the mean scale scores of minority women are comparable to the mean scale scores of white women. Likewise, the percentage of minority women who believe discriminatory attitudes contribute to the underrepresentation of women in engineering is comparable to the percentage of white women. In other words, the perceptions of minority and white women with regard to the extent to which barriers contribute to the low numbers of women in engineering are similar.

With regard to the differences between experiences of minority and Caucasian women, scores of minority women tended to be higher than white women on the personal ability to deal with the program scale, the sense of belonging scale and the independent discrimination variable. It is important to note, the differences in means are statistically significant for the "sense of belonging" scale, i.e., minority women have encountered in their programs of study problems with a sense of belonging to a more significant degree than have Caucasian women.

Concerning the differences between minority men's and women's perceptions of the extent to which the barrier scales contribute to the low numbers of minorities in engineering, mean scale scores for minority women were consistently higher than the mean scale scores for minority men. Additionally, the percentage of minority women believing discriminatory attitudes contribute "a lot" to the underrepresentation of minorities in engineering was notably higher than the percentage of minority men.

With regard to the differences in the experiences of minority men and women, mean scale scores of minority women were consistently higher than the scores of minority men for each of the three scales. Likewise, 52% of minority women as compared with 27% of minority indicated that they had experienced discriminatory attitudes in their engineering programs.

In sum, of the three groups tested in this study, minority women, white women and minority men, on two of the three scales, the personal ability to deal with the program scale and the sense of belonging scales, minority women had the highest mean scale scores. Similarly, the highest percentage of respondents reporting having experienced discriminatory attitudes in their programs was minority women.

It is interesting to note, of the three groups on two of the three scales, the personal ability to deal with the program scale and the support from outside source scale, minority men had the lowest mean scale scores. Likewise, the percentage of minority men reporting having experienced discriminatory attitudes was lower than the percentage of minority women and white women.

Data indicate there is little support for the second hypothesis:

> There is a greater potential for attrition among minority women because they experience "systemic barriers to retention" to a greater extent than do white women or minority men.

With regard to the extent to which problems with barriers have influenced all women to consider leaving their programs, the results are significant. For each of the barrier scales, women with scale scores greater than the median are more likely to contemplate leaving their program of study to a more significant degree than are women with scale scores less than the median.

In a comparison of the barrier scales/dependent variable relationship for minority women versus Caucasian women, data indicate their are non-significant differences between the responses of minority women with scale scores greater than the median and minority women with scale scores less than the median. This was similarly true for minority men.

A qualitative analysis of the content of minority men's and women's responses to an open-ended question suggests minority women have experienced problems with a sense of belonging to a greater degree than have minority men. Similarly, minority women appear to have greater difficulties with discrimination on the part of faculty or others than do minority men. Content analysis further suggests the experiences of minority women may be more closely linked with gender differences as opposed to race differences, race and gender differences, or neither race nor gender differences.

In support of social reproduction theory

Ideally, to gain support for Pierre Bourdieu's social reproduction theory, the experiences of Caucasian women, minority men and minority women

should be empirically tested against the experiences of the dominant group, i.e., Caucasian men. This, however, was beyond the scope of this thesis. Yet, from the comparison of the experiences of minority women to those of Caucasian women and minority men, there are indications Bourdieu's theory, and, thereby, the class analysis view, may be supported.

Although the differences tend not to be statistically significant, data indicate minority women experience barriers in their engineering programs to a slightly greater degree than their Caucasian female and minority male cohorts. This supports Bourdieu's hypothesis with regard to the effect of the social structure on the non-dominant class.

Drawing on Bourdieu's social reproduction theory, minority women experience barriers in their engineering programs due to their inherent inability to obtain two of the three characteristics, i.e., the "correct" gender and race, necessary to acquire the "objective mechanisms" for educational success. The reproduction of social inequities within engineering programs is generated by the lack of institutional mechanisms to properly support and hone the talents of minority women and ensure their success in their programs of study. As a result of their inability to obtain the objective mechanisms for achievement in the educational system, engineering degree attainment is even more elusive for minority women than for Caucasian women and minority men. The data allude to this phenomenon.

Data also indicate the correlation between the barrier measures and an individual's decision to leave his/her engineering program tends to be stronger for minority women than for Caucasian women and minority men. These findings are consistent with Bourdieu's hypothesis that an individual's

educational success is directly dependent upon his or her acquisition of the mechanisms of the dominant class.

Limitations

There are several limitations to the study, the most significant being the small sample size of minority men and women. According to Central Limit Theorem, "the larger the sample size, the closer the sampling distribution of means will come to (1) being normally distributed around the population mean and (2) having a mean equal to the population mean" (Wright, 1986). In this thesis, neither of the two suppositions can be ensured.

Another limitation of the study resulted from the inability to distribute a second wave of questionnaires. The overall response rate was, therefore, less than it potentially could be.

Excluding Caucasian men from the total sample was, yet, another limitation of the study. By failing to compare the experiences of Caucasian men to those of Caucasian women, minority men and minority women, there is no true empirical support for Pierre Bourdieu's social reproduction theory and the existence of a dominant class culture.

This thesis is also limited by its failure to survey women and minority engineering students who have left their engineering programs. Reasons for the high attrition rates among women and minorities, therefore, cannot be accurately assessed. Rather, the study can only test the motivations behind an individual's consideration of leaving his or her program.

Future research

Future research in this area should essentially expand on the limitations of this study. Increasing the sample size of minorities should be the first priority. Since Iowa has such a small minority population, expanding the study beyond the borders of the state is necessary for achieving a representative sample.

As a means of conducting a truly empirical test of Pierre Bourdieu's social reproduction theory, the experiences of Caucasian men should also be examined. These experiences can, thereby, be compared to those of Caucasian women, minority men and minority women to determine whether one group experiences the barriers to a significantly greater degree than another group.

An examination of the motivations behind individuals' decisions to leave their engineering programs is another area for future research. The experiences of Caucasian men, Caucasian women, minority men and minority women should be assessed to ascertain the reasons for the high attrition rates in engineering programs. Additionally, the experiences of Caucasian men who have left their programs should be compared to those of Caucasian women, minority men and minority women to determine why the attrition rates for the latter groups is so much higher than the former.

Future research should examine the experiences of women and minorities who are attending all women or minority colleges. Results from this research can be compared to the results of research conducted on co-ed/inter-racial universities to determine the relationship between one's environment and the extent to which an individual experiences the barriers.

Pierre Bourdieu's social reproduction theory concentrates on class differences. This is, yet, another area for future research. Class backgrounds of all current and former engineering students should be compared and examined.

A comparison of the differences among minority groups is also an area for future research. Research of this type would, thereby, assess the possibility of one minority group experiencing the barriers to a significantly greater degree than another minority group.

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APPENDIX A

Survey Instrument

I am interested in learning about you and how your undergraduate engineering program meets your needs. Please answer each of the following questions by **CIRCLING** the appropriate response(s) or by **FILLING IN** the blank. Thank you for your time and assistance.

1. What is the highest degree you anticipate completing?

   1. Bachelors
   2. Masters
   3. Ph.D.

2. What is your academic major?_____
   (No Abbreviations Please)

3. As of **Spring** semester **1992** were you a....

   1. Freshman
   2. Sophomore
   3. Junior
   4. Senior

4. What is your current G.P.A. (on a 4 point scale)? ___.___ ___

5. To what extent have faculty members acted as an advocate for you? (For example, helping you find jobs or funding, easing bureaucratic tangles, etc.)

   A great deal 1 2 3 4 5 6 7 Very little

6. To what extent have your peers acted as a support group for you? (For example, setting up study sessions, making you feel comfortable in your classes, etc.)

   A great deal 1 2 3 4 5 6 7 Very little

7. How many instructors in your program of study have been women?

   1. None
   2. 1 - 3
   3. 4 or more

8. How many instructors in your program of study have been from a minority group?

   1. None -----> Go to question 10
   2. 1 - 3
   3. 4 or more

9. From which minority groups were your instructors? Please circle **ALL** that apply.

   1. Native American
   2. African American
   3. Hispanic (Spanish American)
   4. Asian American or Pacific Islander
   5. Other

10. Since you have been in the engineering program at your current university, have you seriously considered leaving for any reason?

    1. Yes, very seriously
    2. Yes, somewhat seriously
    3. No ----> Go to question 12

11. Why did you consider leaving? Please circle **ALL** that apply.

    1. Health Problems
    2. Uncertainties about career goals
    3. Doubts about your academic ability
    4. A lack of mentors and/or role models
    5. The absence of peer support systems
    6. The absence of faculty networking opportunities
    7. Unsupportive attitudes of advisors
    8. Problems with instructors
    9. Other, please specify_____

12. As an engineering student, have you had any uncomfortable experiences in your academic program?

    1. Yes ----> Please specify_____

    _____

    _____

    2. No

13. What is your current age? _____

14. What is your sex?

    1. Male
    2. Female

15. Are you an American citizen?

    1. Yes ----> Please continue to question 16.
    2. No ----> Please continue to question 17.

16. If you answered **YES** to Question 15, what is your ethnic/racial origin?

    1. Native American
    2. African American
    3. Caucasian (Not Hispanic)
    4. Hispanic (Spanish American)
    5. Asian American or Pacific Islander
    6. Other ----> Please specify _____

17. In the past, fewer women and minority members have pursued careers in engineering than have white males. The reasons listed below have been suggested as factors contributing to the low numbers of women and minorities in these fields. Based on your observations and experiences, how much do you think these factors contribute to the under-representation of women and minorities in engineering fields today?

In column 1, please indicate the degree to which you believe each factor listed below has contributed to the under-representation of **WOMEN** in this field by circling the appropriate response.

In column 2, please indicate the degree to which you believe each factor listed below has contributed to the under-representation of **MINORITIES** in this field by circling the appropriate response.

In column 3, please indicate whether these factors have been a problem for **YOU** by circling the appropriate response.

	Women			Minorities			You	
	None	Some	A Lot	None	Some	A Lot	Yes	No
Lack of encouragement from teachers or counselors	1	2	3	1	2	3	1	2

	Women			Minorities			You	
	None	Some	A Lot	None	Some	A Lot	Yes	No
Limited information about possible jobs and training opportunities	1	2	3	1	2	3	1	2
Lack of encouragement from family and friends	1	2	3	1	2	3	1	2
Lack of confidence in ability to handle the work	1	2	3	1	2	3	1	2
Lack of contact with women/minorities in the engineering field	1	2	3	1	2	3	1	2
Limited opportunities for teaching and research assistantships	1	2	3	1	2	3	1	2
Competitive atmosphere in engineering classes	1	2	3	1	2	3	1	2
Discriminatory attitudes toward women/minorities on part of faculty or others in engineering classes	1	2	3	1	2	3	1	2
Limited opportunities to join informal study and/or social support groups with other students	1	2	3	1	2	3	1	2
Limited mentoring experiences	1	2	3	1	2	3	1	2

	Women			Minorities			You	
	None	Some	A Lot	None	Some	A Lot	Yes	No
Limited opportunities to participate in informal groups with professors	1	2	3	1	2	3	1	2
Inadequate academic advising and/or career counseling	1	2	3	1	2	3	1	2
Limited opportunities for meaningful internships in the field	1	2	3	1	2	3	1	2

APPENDIX B

CORRELATION MATRIX

	Q17c1	Q17c10	Q17c11	Q17c12	Q17c13	Q17c2	Q17c3
Q17c1	1.00						
Q17c10	.22	1.00					
Q17c11	.25	.34	1.00				
Q17c12	.33	.13	.21	1.00			
Q17c13	.16	.16	.19	.13	1.00		
Q17c2	.18	.15	.13	.30	.26	1.00	
Q17c3	.14	.09	.14	.08	.22	.20	1.00
Q17c4	.03	.10	.06	.10	.05	.08	.08
Q17c5	.19	.31	.15	.12	.08	.18	.08
Q17c6	.12	.27	.26	.06	.35	.19	.06
Q17c7	.19	.11	.20	.16	.07	.20	.02
Q17c8	-.06	-.06	.06	.07	.05	.05	.02
Q17c9	.10	.22	.28	.04	.08	.08	.13

	Q17c4	Q17c5	Q17c6	Q17c7	Q17c8	Q17c9
Q17c4	1.00					
Q17c5	.18	1.00				
Q17c6	.03	.07	1.00			
Q17c7	.27	.16	.06	1.00		
Q17c8	-.03	-.05	.04	-.05	1.00	
Q17c9	.07	.14	.18	.15	.04	1.00

APPENDIX C

ROTATED FACTOR MATRIX

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Q17c1	.21	.71	.07	-.01	-.22
Q17c10	.65	.15	.11	.06	-.33
Q17c11	.68	.28	.06	.05	.10
Q17c12	.01	.80	.09	.11	.14
Q17c13	.18	.08	.76	-.09	-.01
Q17c2	-.03	.42	.54	.21	.06
Q17c3	-.00	.02	.61	.15	.01
Q17c4	-.01	-.11	.13	.80	.04
Q17c5	.29	.17	.06	.38	-.36
Q17c6	.52	-.05	.48	-.16	-.03
Q17c7	.16	.25	-.03	.65	.00
Q17c8	.10	.05	.05	-.02	.86
Q17c9	.66	-.10	.00	.22	.17