Retention of Underrepresented Students in Engineering Degree Programs: An Evaluation Study

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A Dissertation
Submitted in Partial Fulfillment
of the Requirements for the degree of
Doctor of Education
in Curriculum and Instruction

Northern Arizona University

May 2006

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CHAPTER 1

INTRODUCTION

Overview

In a world that is rapidly advancing technologically, quality science and engineering (S&E) education is critical to producing a competent and competitive workforce in the United States. Minorities and women make up a significant and increasing portion of the labor force in the US, yet they do not earn S&E degrees at the same rate as the white male majority (National Science Board, 2002). Since the 1970's as one result of the Civil Rights movement, efforts have been made to increase the numbers of underrepresented students entering the S&E pipeline. After three decades of targeted recruitment efforts by universities and colleges, entrance of minority students into S&E degree programs has increased, but graduation rates still lag far behind those of their white male peers (National Science Foundation, 2002). This issue puts the onus of providing successful, relevant S&E educational experiences for underrepresented students on the programs and institutions that recruit and train them. The success of efforts to retain underrepresented students in S&E degrees is crucial to overcome the barriers faced by these students in attaining degrees and entering the S&E workforce. This study will examine issues related to persistence of women and minorities in engineering degree programs, and evaluate the Multicultural Engineering Program (MEP) at a public university in the Western United States. For the purposes of this study the university will be identified by the pseudonym Southwestern Public University (SPU).

Purpose of the Study

National figures for enrollment in engineering and engineering-related degree programs reveal a student population heavily skewed toward white males who make up more than 80% of students in those programs (National Science Foundation, 2002). Numbers of women and minorities engineering degrees is far below their representation in the U.S. population. This lack of representation will be even more pronounced as the projected growth of minority populations in the next twenty years will result in a U.S. population that is increasingly diverse. This will mean that *very large* numbers of minorities earning degrees in higher education will be required to maintain a presence in

the S&E workforce which is proportionate to their presence in the population at large (Barton, 2003). To date, this has not been achieved. Many studies have sought to discern reasons for lack of representation of women and minorities in science, mathematics and engineering degree programs. Studies related to minority students point to, among other factors, lack of pre-college academic preparation, financial difficulties, and barriers related to being first generation college students (e.g. Adelman, 1999; Maple & Stage, 1991; May & Chubin, 2003). Studies related to female student underrepresentation in S&E fields have determined that women leave not from a lack of academic ability, but because of socio-cultural factors associated with being in a male-dominated environment (Hall & Sandler, 1982; National Science Foundation, 2002; Seymour & Hewitt, 1997). A few studies have sought to discern why students of color are retained at such low levels once they do matriculate into S&E degree programs (e.g., National Center for Education Statistics, 2000a; Quality Education for Minorities Network, 1997; Seymour & Hewitt, 1997) but there is room for additional study. This study seeks to apply the lenses of previous research to a specific program aimed at increasing persistence of underrepresented students in engineering and engineering-related degree programs, and to uncover additional information on factors that influence these students to persist.

Context of the Study

SPU offers four degree programs in engineering: electrical engineering, mechanical engineering, civil engineering and environmental engineering, plus two engineering-related degree programs in computer science and construction management. Between the years 1990-1999, minority enrollment in engineering nationwide ranged between 0.7% for Native Americans to 8.8% for African American students. Minority enrollment figures for engineering programs in this study are close to the national averages except for a proportionally higher number of Native American students (6.8% as compared to 0.7% nationally). This may be due in part to the university's proximity to Native American reservations as well as efforts to recruit Native American students through bridge programs and outreach. Nationwide female enrollment in engineering for the same period averaged 18%. Female engineering student enrollment at SPU is slightly

lower for most majors averaging 14% and higher for civil and environmental engineering at 25% of total enrollment.

In 1994, the Multicultural Engineering Program (MEP) was created to offer various forms of assistance to underrepresented minority students and first generation college students in engineering degree programs at SPU. Services offered through the MEP include a summer bridge program for students who will enter the university in the subsequent fall semester, a peer mentoring program, tutoring services, social activities, and a source of information on scholarships and internships. The MEP has never undergone a formal evaluation to determine the strengths and weaknesses in their efforts to retain minority engineering students, nor have the factors influencing retention of underrepresented minorities in engineering programs been examined. The purpose of this study is twofold: to examine the worth and merit of the various components of the MEP and to bring to light factors that both support and hinder female and minority students in pursuing engineering and engineering-related degrees at SPU.

Statement of the Problem

This evaluation study seeks to examine the strengths and identify areas for improvement in the MEP efforts to successfully retain minority students in engineering and engineering-related degree programs at SPU and also to determine what other factors influence retention of this population. The following questions will guide the study.

- 1. What factors influence retention and graduation of underrepresented women and minority students in engineering and engineering-related degree programs?
- 2. How do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
- 3. Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?
- 4. Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

Significance of the Study

The evaluation undertaken in this study is considered a formative evaluation, that is, an evaluation that is done on a program that is in operation but seeking to make programmatic improvements (Scriven, 1967). Patton (2002, p. 220) stressed that formative evaluations are intended to "form or shape the thing being studied," hence producing useful and usable results for informing programmatic decisions. Results of the evaluation will be shared with the major stakeholders in the program, i.e., the program director, engineering department chairs and faculty, and the students who are directly impacted by the MEP services. The results of this evaluation have the potential to impact decisions on how to best utilize the resources of a five-year grant awarded to the engineering departments for improving retention of underrepresented students. The MEP is receiving a portion of the grant funds for program operation and enhancements. This study will help to inform decisions on where to focus programmatic efforts in this respect so that they may be sustained beyond the duration of the grant.

There is also the potential for this evaluation to help program staff and engineering faculty gain an understanding of barriers to degree completion of underrepresented students and devise means for addressing those barriers and the unmet needs of this student population. And lastly, universities across the U.S. have multicultural or minority engineering programs with elements common to those of the program at SPU (National Association of Minority Engineering Program Administrators, 2004). Very few studies of evaluations of MEPs have been conducted and/or reported in the literature. This study may serve to inform others on conducting similar programmatic evaluations at institutions beyond the one in this study.

Rationale for Research Design

The purpose of this study is to determine the strengths and weaknesses in engineering and engineering-related degree programs in supporting women and minorities to graduation. Evaluation research is an appropriate choice of research design to accomplish the goals of this study because it seeks, through multiple lines of evidence, to determine the effectiveness of program activities toward reaching the goals of the program. In addition, good evaluations also seek to reveal any unintended outcomes or

side effects of the program upon its stakeholders (Scriven, 2004) and give special attention to antecedents (conditions in existence prior to program inception) and transactions (encounters and interactions between stakeholders) (Stake, 1967).

A commonly accepted definition of evaluation is "to determine the worth, merit or value of something" (Scriven, 1967). In defining "utilization-focused evaluation," Patton (1997) stresses that such evaluation "begins with the premise that evaluations should be judged by their utility and actual use; therefore, evaluators should facilitate the evaluation process and design any evaluation with careful consideration of how everything that is done, from beginning to end, will affect use" (p.20). Therefore, evaluations should not be undertaken lightly, but should be designed and implemented with a specific purpose in mind, in this case program improvement.

The evaluation proposed in this study is intended to be a formative evaluation. As previously stated, formative evaluations are done with the purpose of improving programs. Formative evaluations can give stakeholders useful information about the aspects of a program that are working well or not working well. They can provide information about the perceptions of the intended program audience as to the program's effectiveness so that decisions can be made about program activities that are based on authentic and accurate data rather than on the assumptions of the program planners.

Because the focus of this study is on underrepresented students in engineering, particular attention will be paid to cultural competence in the evaluation design. Thompson-Robinson, Hopson, and SenGupta (2004) assert that the common thread between culture and evaluation is the concept of values: "Culture shapes values, beliefs, and worldviews. Evaluation is fundamentally an endeavor of determining values, merit, and worth" (p.6). Defining the views of minority groups is essential to this evaluation and the evaluator has "an obligation to give them special consideration" (House, 1993, p. xv).

Research Ouestions

For the results of an evaluation to be utilized, it is essential that the evaluator "develop a working relationship with intended users to help them determine what kind of evaluation they need" (Patton, 1997, p. 21) Conversations with the director of the engineering programs and with the director of the MEP led to the development of the

research questions in this study. Once the idea for the study was developed, a two page description of the study and its goals was sent out via the engineering director to the dean of the college, and to the entire faculty in the engineering and engineering-related degree programs with a request for comments and insights. Many useful comments were returned. An additional conversation with the director of the MEP helped to further refine the evaluation focus. As a result of this process, the following research questions were developed:

- 1. What factors influence retention and graduation of underrepresented women and minority students in engineering and engineering-related degree programs?
 - a. What social integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: peer interactions, faculty interactions, clubs, and competitions.
 - b. What academic integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: quality of instruction, difficulty of courses, and pre-college academic preparation.
 - c. What factors external to the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: cultural, community, and family influences.
- 2. How do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
 - a. How do minority students who utilize MEP components compare academically to minority students who do not utilize MEP components?
 - b. How do students who utilize MEP components compare to minority students who do not utilize MEP components in terms of satisfaction with their degree programs?
- 3. Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?
- 4. Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

Definitions of Key Terms

Underrepresented Students:

For the purposes of this study, underrepresented students in engineering are defined as all females and any male of Hispanic, African-American or Native American descent.

Evaluation:

Judging the worth or merit of something (Scriven, 1967).

Evaluand:

A generic term for whatever is being evaluated – e.g. person, performance, program (Scriven, 1991).

Formative Evaluation:

An evaluation conducted during the development or improvement of a program done with the intent to improve (Scriven, 1967).

Program:

A program is a complex of people, organization, management, and resources that collectively make up a continuing endeavor to reach some particular educational, social, or commercial goal (Worthen, Sanders, & Fitzpatrick, 1997).

External Evaluator:

External evaluators are those with no long-term, ongoing position within the program or organization being evaluated (Patton, 1997).

Stakeholder:

Stakeholders are those who have a stake in the program to be evaluated, or in the evaluation's results (Worthen, Saunders, & Fitzpatrick, 1997, p. 192).

Engineering-related degrees:

Engineering-related degrees include computer sciences and construction management.

Limitations of the Study

This study is limited to an evaluation of the Multicultural Engineering Program and factors related to retention of underrepresented students in engineering and engineering-related degree programs within a single specified institution identified in this study as Southwestern Public University. Stakeholders in the evaluation will include

minority and women students currently enrolled in engineering programs, staff of the MEP, and current faculty members in engineering. Lacking will be the perspective of underrepresented students who have graduated from the university and past faculty and program directors. Findings of the evaluation are highly contextual and may not be generalizable to similar programs beyond this university.

Summary

In this introductory chapter, the evaluation study designed to assess the worth and merit of activities and programs associated with underrepresented student persistence including an evaluation of the Multicultural Engineering Program at Southwestern Public University was introduced. The underlying purpose and rationale for the study were discussed, and research questions to be examined were addressed. Additionally, key terms utilized in the study were defined and the limitations of the study were addressed.

Following this introductory chapter, Chapter 2 will provide an analysis of the literature relevant to issues influencing retention of underrepresented minority students in engineering degree programs. Chapter 3 provides a contextual background for the study including an analysis of enrollment and retention of women and minorities at the university and programmatic levels as well as a description of the MEP and its components. Chapter 4 will address research methodology and data analysis utilized in the study. Chapter 5 will describe findings of the study. The final chapter, Chapter 6, will provide discussion of findings and recommendations.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

This chapter reviews current scholarly literature related to this dissertation study. The literature review will encompass two major areas of research. The first component to be addressed includes a review of research related to undergraduate student retention. This section will begin with an examination of the leading models related to student retention in higher education. This will be followed by an overview of underrepresented enrollment and persistence in science and engineering (S&E) programs to provide a broad framework for situating the research in this study. This section of the literature review will conclude with an examination of factors specifically affecting retention of underrepresented minority and female students in S&E undergraduate degree programs to provide a narrower context for the current study.

The second component of the review of the literature will be concerned with examining educational program evaluation as both a field of study and as an appropriate choice of research methodology for this study. This will include a discussion of the ways in which evaluation differs from other forms of scholarly research, followed by an examination of cultural competence in evaluation. This part of the literature review will conclude by examining evaluation of programs specifically related to engineering student retention.

Retention in Higher Education: Models and Research.

Factors affecting student retention and attrition from higher education have been the subject of a vast and varied amount of research in the past thirty years. In seeking to describe student attrition from higher education, two major theories have gained prominence in the field. These two theories, the "student integration model" and the "student attrition model," will be described in this section of the literature review. In addition, key studies that have sought to validate the models as well as to supplement

them will be described including a look at a theory of student involvement and its affect on student persistence.

The Student Integration Model

Based on the work of Tinto, (1975; 1993) the student integration model is the theory that has gained prominence in the field of higher education retention. Braxton (1997) has stated that Tinto's model possesses "near-paradigmatic status in research on college student departure." As such, much of the subsequent work on student persistence and attrition uses Tinto's model as a point of comparison or departure.

Tinto's theoretical model of student attrition has its roots in Durkheim's theory of suicide which hypothesizes that an individual is more prone to suicide when not sufficiently integrated into the fabric of society (Tinto, 1975; 1993). The student integration model applies the concept of integration to college students. Essentially, students drop out when they have not achieved a sufficient level of integration into the fabric of college life. In other words, the "fit" between person and institution is not conducive to persistence.

Figure 1 depicts the various interactions involved in Tinto's model. The student integration model postulates that students enter an institution with certain attributes, including family background (e.g., social status, values), individual attributes (e.g., sex, race, and ability) and pre-college schooling (e.g., G.P.A., academic course work). These attributes influence the goal and institutional commitments that the individual brings to the college environment. Goal commitments refer to student held goals of completing a degree. Institutional commitments refer to commitment to completing the degree at the chosen institution. Once enrolled, students have academic and social experiences, including interactions with faculty and peers, which interact to lead to new levels of goal and institutional commitment. Tinto stated that "in the final analysis, it is the interplay between the individual's commitment to the goal of college completion, and his commitment to the institution that determines whether or not the individual decides to drop out from college" (Tinto, 1975, p. 96). Social and academic activities and experiences during college can serve to either reinforce or weaken the individual's goal and institutional commitments leading to decisions of whether to remain or leave the institution.

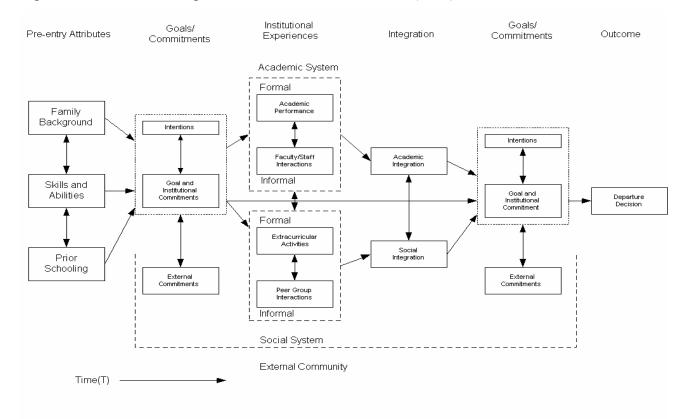


Figure 1. The Student Integration Model. Taken from Tinto (1993).

In seeking to test the utility of the Tinto model, Braxton, Sullivan, and Johnson (1997) conducted a meta-analysis of peer-reviewed studies that used the social integration model as a basis for empirical research. These authors examined the studies with respect to fifteen testable propositions inherent in the student integration model. They concluded that the empirical evidence for the testable propositions lends itself to partial support for Tinto's model, mainly in residential universities. They do not advocate abandoning Tinto's model and see value in it for studies involving single institutions. Braxton and colleagues recommended future revisions of the model based on continued research in the field. They also advocated for more research that seeks to integrate missing components of the theory into the original model.

Critics of Tinto's model include Tinto himself who in later works (1982; 1993) acknowledged limitations in the original theory in that it underestimated the role of finances in attrition, did not distinguish between factors leading to transfer versus dropout, and was not well suited to studies of commuter and non-residential institutions.

These factors were taken into account in the second most cited theory of student dropout, the "student attrition model" described in the following section.

The Student Attrition Model

Bean and Metzner (1985) suggested that Tinto's student integration model did not take into account the external factors that influence nontraditional students when making decisions of whether to stay or leave an institution. In developing the "student attrition model," Bean and Metzner incorporated the external factors that act upon nontraditional students including financial pressures, family responsibilities, and the influence of employers and friends outside of the college environment. For nontraditional students, social variables from outside of the university are of greater importance than the social integration within the university put forth in the student integration model. Older, nontraditional students and commuter students tend not to be as involved socially within the university structure and are more affected by friends, family, and employer support in their life outside of the college environment. Bean and Metzner termed these external factors "environmental factors." Environmental variables hold greater importance for nontraditional students than even academic variables:

When academic variables are good but environmental variables are poor, students should leave school, and the positive effects of the academic variables on retention will not be seen. When environmental support is good and academic support is poor, students would be expected to remain enrolled—the environmental support compensates for the low scores on the academic variables. (Bean & Metzner, 1985, pp. 491-492)

Cabrera and co-workers (Cabrera, Castaneda, Nora, & Hengstler, 1992) conducted a study which sought to examine the convergence between the Student Integration Model and the Student Attrition Model by applying both models to the same group of students. They concluded that the Student Integration Model is more robust in validating the hypotheses inherent in the model than is the Student Attrition Model, but the Student Attrition Model explained more of the variance observed in student persistence (44% vs. 38%) than the Student Integration Model. These authors argued that the models are similar in most respects except in the effect of external factors argued for

in the Student Attrition Model and that a convergent model is the most effective for understanding student persistence in higher education.

In a follow-up study (Cabrera, Nora, & Castaneda, 1993) described the results of a study using structural equations modeling to test the integrated theory approach. These authors stated that:

Both models regard persistence as the result of a complex set of interactions over time. The two models also argue that precollege characteristics affect how well the student would subsequently adjust to the institution. Further, the two models argue that persistence is affected by the successful match between the student and the institution. A close examination of the two theories...apparently indicates that a high degree of overlap exists across the two theories in terms of organizational factors (courses and academic integration) and commitments to the institution (institutional commitment, institutional fit and quality). (p. 125)

Results of the study indicate that the largest total effect on student persistence was accounted for by the student's intent to persist, followed by grade point average, institutional commitment, encouragement from friends and family, goal commitment, academic integration, attitude toward finances, and lastly, social integration. The results represent evidence for integration of the Tinto and Bean models for an effective model of student persistence.

Student Involvement

Other research that has served to inform on issues of persistence of college students includes the work of Astin (1975; 1984; 1993). Astin has looked extensively at the impact of student involvement on persistence in higher education. He defined student involvement as:

the amount of physical and psychological energy that the student devotes to the academic experience. Thus a highly involved student is one who, for example, devotes considerable energy to studying, spends much time on campus, participates actively in student organizations, and interacts frequently with faculty members and other students. (Astin, 1984, p. 297)

Astin's (1993) longitudinal study involving 25,000 students in more than 200 colleges and universities found several forms of student involvement that fostered positive

outcomes including academic development, leadership development, growth in problem-solving and critical thinking skills, and indirectly, persistence. Student peer group interactions were found to be the single most important source of influence on an undergraduate's academic and personal development. After peer group, student-faculty interactions represented the most significant aspect of development. In the study, student-faculty interaction could take a number of forms including being a guest in a faculty member's home, assisting a faculty member in research or teaching, and just talking with a faculty member outside of class. Although not constituting a model of student persistence in itself, Astin's Student Involvement Theory lends itself in support of the Student Integration and Student Attrition Models by sustaining the idea that commitment to academic and institutional goals is fostered through extensive social and academic integration on the part of the student.

Summary

The models and research presented in this section have underlined factors that affect persistence of students in higher education. These factors include social and academic integration into an institution including: interactions with peers and faculty members, and levels of involvement of the student in the institution. Persistence factors identified in the models also include factors external to the college environment including support of family, friends, and employers, financial pressures, and obligations to family. The models described in the previous section can serve as a lens through which to examine the data in the present study. However, these models attempt to take a broad view of student persistence and attrition, seeking to explain factors affecting all students across university and college settings.

In contrasting the three models presented here, the Student Integration Model has as its focus the effects of social and academic experiences on an individual's level of commitment to a particular degree and to the institution in which they have enrolled whereas the Student Attrition model raises issues associated with non-traditional students such as financial and family responsibilities that may not act upon typical undergraduate residential students. The Student Involvement Theory explicitly discusses the factors that

are important to integration of students into the institution such as peer and faculty interactions and involvement in campus activities.

The present study focuses on an examination of persistence factors specific to minority students in engineering and engineering-related degree programs. While not designed to test the models of student persistence previously described, this study will seek to inform on how ethnic and cultural influences affect student integration into the institution in the study, and into the culture of science-specific degree programs.

The next section of this literature review will examine research related to the persistence of minorities in science and engineering (S&E) programs. It will begin with a look at the current literature on enrollment and retention of underrepresented populations in S&E programs and go on to examine studies related to why these populations stay in or leave S&E programs.

Underrepresented Students in Science and Engineering Overview

Members of the engineering profession and educators of engineering students are increasingly concerned with the lack of diversity in the engineering workforce in the United States (Chubin, May, & Babco, 2005). When examining racial/ethnic and gender gaps in science and engineering fields, varying statistics are presented depending on the definition of S&E utilized. The National Science Foundation includes social and behavioral sciences in the definition of S&E. When social and behavioral sciences are included in the definition of S&E, the gender and racial/ethnic gaps are narrower than when the definition includes only natural sciences and engineering (National Center for Education Statistics, 2000a). Because most of the national analyses of S&E enrollment and persistence use the NSF definition, it is the definition that will be utilized in this review. Therefore, the following fields are considered S&E fields: engineering, physical sciences, biological/agricultural sciences, Earth, atmospheric and ocean sciences, mathematics/computer sciences, social sciences, and psychology.

Minorities and women are considered underrepresented in science and engineering fields because their presence in those fields falls far below their representation in the overall U.S. population (see Table 1). Minority women may be

considered to be subject to the "double jeopardy" of being female and minority, both subgroups being largely underrepresented in traditional S&E fields. While efforts to recruit underrepresented students into S&E fields have resulted in more students intending to major in these areas, for certain populations, projected population growth rates will cause the gap between numbers in the population and numbers in S&E careers to widen even further in the next decade (Barton, 2003). Asian Americans are an exception to the issue of underrepresentation in S&E. As shown in Table 1, Asians are actually overrepresented in S&E occupations relative to their presence in the U.S. population and are therefore not included in the definition of underrepresented in science and engineering education or within the bounds of this study.

Table 1. Percentage of U.S. population and employment in S&E occupations by gender and race/ethnicity. Source: U.S. Census Bureau, 2005: www.census.gov

	Portion of U.S.	Employed in S&E
Gender	Population (%)	Occupations (%)
Male	49.1	74.6
Female	50.9	25.4
Race/Ethnicity		
White	69	76.4
Black/African American	12.2	4.4
Hispanic/Latino	13.0	3.4
American Indian/Alaskan Native	0.7	0.3
Asian	3.8	14.0

Enrollment and persistence of underrepresented students in science and engineering (S&E) programs has been the subject of a broad body of research including longitudinal studies relying mostly on survey data and statistical analyses (e.g., National Center for Education Statistics, 2000a), retrospective reviews of published data (May & Chubin, 2003), and in-depth ethnographic studies (Seymour & Hewitt, 1997). Many of these studies will be examined in the following sections of this literature review.

Enrollment in S&E

In recent decades, women and minorities have shown an increasing intention to major in science and engineering. By the year 2000, women made up 44% of first-year college students intending to major in an S&E field, while minorities made up 20% of intended majors (Higher Education Research Institute, 2001). These figures have

increased considerably from the 1970's and earlier. However, while intention to major in S&E fields is increasing among underrepresented students, retention rates still lag behind those of white male students.

Rates of enrollment for women and minorities in engineering degree programs are lower than those for other sciences considered in the Higher Education Research Institute study. African American, Hispanic, and Native American freshman are more likely than whites or Asians to major in social and behavioral sciences than in engineering or the physical sciences (National Science Foundation, 2002). Demographic studies reveal that engineering is still predominately the territory of white, male students with women and minorities continuing to be underrepresented in the field (National Science Board, 2002). The latest statistics for enrollment in engineering degree programs, (National Science Foundation, 2004) show that in 2002, White students made up 69.8% of undergraduate engineering students, followed by Asians (10.4%), African Americans (7.6%), Hispanics (7.5%), and Native Americans (0.6%). Women make up 18.1% of engineering students across the United States. Interestingly, Asian, African American, Hispanic and Native American women accounted for larger percentages of engineering enrollment of their respective racial/ethnic groups than did white women during the decade of the 1990's (National Science Foundation, 2004). It is relevant to note that overall there has been a trend of decreasing undergraduate engineering enrollment for all students in the last decade.

Persistence in S&E Programs

A longitudinal study was conducted between 1992 and 1998 by the Center for Institutional Data Analysis and Exchange (C-IDEA) that surveyed 119 colleges and universities of varying size and type that offer S&E degrees. The aim of the study was to provide a means of gathering benchmark data on retention rates in science, math, and engineering education. The C-IDEA study reported that of freshman entering S&E programs in 1992, only 38% had completed an S&E degree six years later. Degree completion rates for minorities in S&E fields were even lower at 24% (National Science Board, 2002). The C-IDEA study also found that retention rates of S&E majors differ by institution, with higher retention rates at more selective institutions, institutions with fewer part-time undergraduates, and at research institutions.

A high percentage of S&E students switch from their initial degree programs to something outside of the sciences. According to a National Center for Educational Statistics longitudinal study conducted between 1990 and 1995, over half of students intending to major in S&E fields explored other majors in their freshman year and switched to other academic disciplines, while 20% dropped out of college completely (National Center for Educational Statistics, 2000). For those who leave engineering, they may choose to stay in the sciences or move outside of the sciences when switching degree programs. Using longitudinal data from a national sample of American undergraduate students, Astin and Astin (1992) found that of those students intending to major in engineering, more than half left for another major, sometimes out of S&E (business or history) or to other sciences (physical sciences, social sciences). Adelman (1997) found that those who switched out of engineering tended to stay in the sciences but moved into computer sciences or physical sciences.

Many factors have been identified that are linked to loss of students from S&E degree programs and specifically from engineering degree programs. In a three year, seven campus ethnographic study of junior and senior students, Seymour and Hewitt (1997) conducted over 600 hours of interviews with more than 300 students who switched out or stayed in science, mathematics, and engineering (SME) degree programs. The seven institutions consisted of three private and four public universities or colleges differing in type and location. The students selected for participation in the study included only those with SAT scores of 650 or higher and thus were students who it was believed would have the ability to handle the rigorous science and math course work. The study sought to bring to light the factors with the greatest impact on the decisions of undergraduates at four-year institutions to switch from science, math and engineering programs. The authors over-sampled women and minority students so that they might understand how they differed from white males. The Seymour and Hewitt (1997) study has become a landmark study in the literature on SME degree attainment due to the depth of exploration into the topic and the rich qualitative descriptions offered by participants in the study. The validity of the results of the study is supported by the large number of participants in the study across multiple institutions, allowing the researchers to triangulate findings, and by the purposeful sampling of students with academic

capabilities that should allow them to succeed academically in S&E majors. Criticisms of the study focus on the "elite" nature of the students selected for the study using the SAT criterion (Adelman, 1998). This may suggest that students with lower entrance scores who may or may not persist in S&E degrees are not heard from in the Seymour and Hewitt study.

Among their findings, Seymour and Hewitt indicate that a major factor in switching decisions for all students was loss of interest in the field (43%). Forty percent of switchers cited non-SME majors offering more interest for them. Poor teaching was identified by a large number of switchers as a factor in their decision to switch (36%). Also identified by more than a fourth of switchers were: "curriculum overload," rejection of S&E careers and lifestyles, and shift to more appealing career options. These and other factors affecting persistence of women and minorities in S&E degree programs will be discussed in depth in the following sections of the literature review.

Factors Influencing Persistence of Women in S&E Introduction

Many studies examining why women leave the sciences and particularly engineering confirm the same thing: women do not leave because they are less academically capable than men. In fact the opposite is often true. Women tend to leave for reasons that are "psycho-cultural" (National Center for Education Statistics, 2000) and not related to academic ability in college-level courses (Adelman, 1998; Astin & Astin, 1992; Goodman Research Group, 2002; McIlwee & Robinson, 1992).

Adelman (1998) utilized data from participants in a thirteen year NCES study to determine the paths taken by students to reach what he refers to as the "curricular threshold" for engineering. Adelman defined the threshold as having completed more than 10 credits of course work from a degree-granting institution and having successfully completed math at the pre-calculus level or beyond plus introductory engineering and engineering graphics courses. Data utilized in the study included eleven years of college transcripts, high school transcripts, test scores and surveys of a nationally representative sample of over 12,000 students from 2500 institutions. Adelman discovered that a higher proportion of women than men have what he refers to as "curricular momentum"

(a strong math/science and overall academic background) coming out of high school to enter and persist in engineering degree programs, yet they choose not to follow the path, or run the risk of switching out once enrolled. He also found that women who leave engineering are more likely to complete a bachelor's degree in another field than are the men who leave. These results offer strong support for the idea that women are certainly academically capable. The study offers insight into the role of academic preparedness for engineering degrees but does not shed light on other cognitive and affective factors that may influence whether women stay or leave. What factors then, support women in persisting in S&E and what influences their leaving?

Self-confidence

Several studies indicate that although women may be academically capable, they often have low self-confidence in their abilities to "do science." Seymour and Hewitt (1997) found that a high-level of self-confidence and the subsequent ability to be assertive in male-dominated environments was a factor that contributed to persistence in female S&E students. This finding was echoed in a longitudinal study conducted by the National Center for Education Statistics (2000) utilizing data from two large nationwide databases. To examine pre-college entry patterns in the S&E pipeline, the National Education Longitudinal Study of 1988 (NELS:88) data were used. NELS:88 survey components included student, parent, teacher and administrator questionnaires. Data were collected for 24,599 students from 1052 private and public 8th grade schools. Data analysis included descriptive analyses as well as logistic regression with the dependent variables being entry or non-entry into S&E degree programs. To examine persistence and attainment of post-secondary S&E education, data from the Beginning Postsecondary Student Longitudinal Study (BPS) were used. BPS survey data from 7932 students who began postsecondary education in the 1989-1990 academic year, and were followed-up in 1992 and 1994 were used in logistic regression and survival/failure analysis. Among the results of the NCES study was the finding that for all S&E students (males included) selfconfidence in intellectual abilities was positively correlated to degree completion. Intellectual confidence and aspirations for advanced S&E studies reduced the effects of parents' education level and financial support, two factors in the study also correlated with degree attainment. In other words, students could overcome the family background

factors that worked against them if their confidence levels were high and they had set high goals for themselves.

Brainard and Carlin (1998) conducted a six-year longitudinal study of women in science and engineering at the University of Washington. Over the course of the study, 672 women were tracked to examine persistence rates, factors affecting retention and the effectiveness of the university's Women in Engineering program activities targeted at increasing enrollment and retention of women in S&E programs. These authors found that as freshmen, women engineering students begin with a high level of self-confidence in their abilities in math and science but that their self-confidence took a significant drop by the end of their first year and never returned to the original level, even as fourth or fifth year students. Results of this study indicate that high levels of self-confidence significantly correlated to, among other factors, favorable ratings of math/science classes, participation in professional societies, and positive influence of advisors. This suggests that self-confidence is an integral part of why women do or do not succeed in S&E programs and that particular attention should be paid to factors that affect the confidence levels of women in the classroom and beyond.

Grandy (1994) conducted a study surveying more than 1600 college seniors who registered to take the GRE and had academic backgrounds in science, mathematics, computer sciences or engineering. Part of this study was aimed at analyzing gender differences in reasons for staying or leaving the S&E pipeline. Among the findings, Grandy discovered that women in S&E programs were less confident in their problem-solving skills than males.

Similar findings are echoed in other studies. A national survey was designed by the Women in Engineering Programs and Advocates Network (WEPAN) to provide data to participating institutions meant to help them identify areas in need of improvement related to academic climate, and to provide data regarding student attitudes on gender and ethnicity differences. Responding to the WEPAN pilot survey were 8076 students at twenty-nine institutions varying in size and geographic location. Students responded to 45 Likert scale items evaluating various aspects of their educational experiences. Results of the study indicate gender differences in confidence ratings for several subject areas,

with women rating their confidence lower than men in engineering and physics classes, as well as their overall academic self-confidence (Brainard, Metz, & Gillmore, 1999).

McIlwee and Robinson (1992) conducted a mixed-methods study that included questionnaires followed by in-depth interviews of engineers who had graduated from two major public universities in southern California between the years 1976 and 1985. The researchers over-sampled women in an attempt to gain an understanding of issues faced by women engineers in the workplace. McIlwee and Robinson discovered that although the women in their study had higher GPAs than the men, more than half of the women interviewed felt unsure about their technical abilities which translated to feeling unsure of themselves in laboratory environments. McIlwee and Robinson relate this finding to socialization experiences that differ between males and females in childhood. As children and adolescents, "tinkering" with mechanical objects is reinforced for boys, while girls often never learn the vocabulary and skills of tinkering. This puts them at a disadvantage in engineering laboratories and in the workplace which tends to be more "hands-on" and applications oriented. These authors did find, however, that for most female engineering graduates academic success overshadowed feelings of technical insecurity, suggesting that given opportunities to succeed, women can overcome confidence barriers in pursuing their studies. While this study offers insights into attitudes and experiences of female engineering graduates, it is questionable to generalize the findings beyond the study. Due to the location of the universities, a high percentage of participants in the study were employed in defense and high tech firms and consisted of only two types of engineers: mechanical engineers and electrical engineers. The two universities from which the engineers graduated are ranked in the mid-tier of engineering education institutions and are similar in geographic and demographic characteristics. Therefore, the findings may not be representative of the engineering profession as a whole.

Henes, Bland, Darby, and McDonald (1995) designed a survey that was administered to students in eleven undergraduate engineering classes at University of California Davis in 1992. The survey contained both closed and open-ended questions related to the educational climate for engineering students at the university. Results of the study indicated that women were less confident than men that they would finish their

degrees and less confident that they would be excellent engineers if they did so. Follow-up interviews of women engineering students as well as faculty and professional engineers indicated loss of confidence and discouragement with engineering were related to feelings of isolation, negative experiences in laboratory classes, lack of role models and a "cold" classroom climate. These authors proposed faculty development workshops meant to raise awareness of issues that women face in the classroom and to develop concrete steps to improve the engineering academic environment. As in the previously described study by McIlwee and Robinson (1992), generalizing the findings of this study should be approached with caution since it was a single institution study. Studies of this nature are important in directly informing the institution involved about issues and concerns of their own students and are invaluable in that respect, but may not necessarily be applied to institutions beyond the bounds of the study unless validated by similar studies at other institutions.

As illustrated, self-confidence returns again and again as a barrier to persistence in S&E programs. It is possible that many other factors relating to loss of women from S&E environments may be linked to low self-confidence. Other factors cited by women as barriers to completion of S&E programs include the competitive environment of engineering classes, lack of female role models, the "chilly" climate that women encounter in the sciences, and poor perceptions of engineering faculty and teaching. It is possible that low self-confidence is interrelated with many of the factors either directly affecting the other factors, or being directly affected by them.

Inappropriate Choice of S&E as a Field of Study

Seymour and Hewitt (1997) found that women more than men choose S&E disciplines because they were encouraged to do so by family, high school teachers, or mentors rather than because of interest in the field. Absent these supportive adults, many women fail to develop intrinsic reasons for achieving in S&E majors. When strong mentoring and extrinsic support is not offered by faculty and mentors in the college setting, such women become discouraged. This may lead to a loss of confidence in their abilities to complete their studies and switching out of S&E degrees. Women with strong intrinsic interest in science and engineering are more likely to persist through the academic and social challenges they face in completing their degrees. Seymour and

Hewitt found that some women with strong intrinsic interest in their majors had also been strongly influenced by teachers, family members or role models *however* they had always felt free to choose their own path.

Loss of Interest in the Major

Possibly related to inappropriate choice of degree, several studies report findings that those who switch out of S&E programs do so because of loss of interest in the major. Moller-Wong and Eide (1997) suggest that loss of qualified students from engineering programs to other degree programs should not necessarily be looked at as student "failure." Migration to another degree may often represent "success" for the student who finds a more appropriate and satisfying career option in another field. However, without examining why students leave S&E and what leads to loss of interest in their degree, S&E programs may continue to lose highly qualified students who may have greatly added to their field had they pursued their studies and gone on into the professional world.

Seymour and Hewitt (1997) found loss of interest to be a major factor in switching for both men and women. In their study, 44% of men and 43% of women cited loss of interest in S&E (being "turned off" by science) as a factor in switching decisions. This appears to be supported in studies of engineering student attrition. Besterfield-Sacre, Atman and Shuman (1997) developed a survey delivered to 417 students over the course of two years at the University of Pittsburgh. The resulting Pittsburgh Freshmen Engineering Survey measures student attitudes toward engineering as a profession and reasons for choosing engineering as a major as well as confidence levels in skills and abilities. Besterfield-Sacre et al. found that one-third of students who left engineering programs in good academic standing said they no longer were interested in studying engineering. Another third cited wanting to pursue a different field of study.

The Goodman Research Group (2002) conducted the Women's Experiences in College Engineering (WECE) project that had as it's aim to identify aspects of the educational experiences of women engineering students that affected retention in engineering. The study involved thousands of undergraduate women at 53 institutions with engineering schools. Of the institutions being evaluated, 26 had formal Women in Engineering (WIE) programs. These schools were matched with a stratified random

sample of 27 schools that did not have WIE programs. Data collected in the evaluation study included on-line student, dean and faculty surveys, and follow-up site visits which included focus group and individual interviews. Their findings support those of Seymour and Hewitt, and Besterfield-Sacre et al. for female engineering students. Women who had left engineering did not do so because of lack of academic ability. Forty-five percent of women who had left engineering programs had A or B averages in engineering course work. Half of the women in the study who had left engineering programs had lost interest in engineering, and one-third indicated attraction to another discipline as a reason for leaving. Women in focus groups most often sited poor teaching and negative climate (e.g. competitive atmosphere, lack of support and discouraging faculty and peers) as reasons for becoming discouraged with engineering and loss of interest. The WECE project was the first of its kind to examine on a large scale, the experiences of undergraduate women in engineering that affect retention and will be described in greater depth later in this literature review.

Part of the attraction to other disciplines may be linked to socialization patterns of women. Women tend to be socialized to humanitarian aims where they can help others and provide benefits to society. For many women, if they do not see the links in science professions to the greater social good provided, they may switch to careers offering more personally satisfying career options such as education where they feel they can have more of a societal impact (Grandy, 1994; Seymour & Hewitt, 1997). In testimony to the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, William Wulf, then president of the National Academy of Engineering, said: "I believe more women will enter engineering when they begin to recognize engineering as a creative, interesting, rewarding career, when they see it as a way to improve people's lives" (Wulf, 1999). Other students may find the sciences too isolating with respect to other people. Astin and Astin (1992) found that "defectors" (both male and female) from science and engineering programs were more attracted to careers that enabled them to work with people and have more "freedom of action" in their work.

Some studies suggest that loss of interest in a degree program may be linked to poor pedagogical practices and low levels of interaction between students and faculty. These factors will be discussed in the following section of this literature review.

Interaction with Faculty, and the Classroom Environment

Referring back to the Tinto (1975) and Bean and Metzner (1985) models of retention discussed earlier in this literature review, interactions with faculty play an integral role in academic integration and commitment to both an institution and to degree completion. Interactions with faculty both in and out of the classroom shape the way students view themselves and the discipline they are studying.

The highest level of interaction students have with faculty is in the classroom. Seymour and Hewitt (1997) found that poor teaching and inadequate advising were among the most offered factors for switching decisions of both male and female S&E students. Thirty-nine percent of women and 33% of men cited poor teaching as contributing to their decisions to leave S&E and 29% of men and 20% of women cited inadequate advising as influencing their switching decision.

Poor interactions with faculty appear to be particularly common in engineering degree programs. Grandy (1994) found that quality of instruction and relationships with instructors were rated lowest by engineering students of all science and mathematics students surveyed in their study. Astin and Astin (1992) found that for male and female engineering students (in contrast to all other science and math disciplines) higher levels of faculty interaction in and out of the classroom had a *negative* effect on persistence:

Students in engineering programs tend to be less satisfied with their faculty and less satisfied with the quality of instruction than are students in other majors. Thus, the greater interaction with faculty may not have the same positive effect on engineering students simply because these interactions are less likely to be perceived as favorable. (p. 4-28)

For women, a classroom climate that promotes their inclusion is important in supporting them in their studies. Women in engineering may be more subject to both overt and subtle sexism in the classroom by male instructors and peers than are women in science fields that have been more fully integrated with female students, such as biological sciences (Goodman Research Group, 2002; McIlwee & Robinson, 1992;

Seymour & Hewitt, 1997). Much has been written on the idea of the "chilly climate" for women in higher education, originating in the work of Hall and Sanders (1982). These authors proposed that women are treated differently than men in the college classroom and are either singled out or ignored by male instructors who either overtly or covertly discourage their participation. Hall and Sanders have been criticized for the original work due to the fact that it was not based on empirical research. Since then, empirical studies have offered mixed support for the concept of a "chilly climate" in the college classroom (Morris, 2003) but it remains an area of focus for many researchers in higher education.

In a longitudinal study on student performance and retention of students at North Carolina State University based on student questionnaire and performance data, Felder, Felder, Mauney, Hamrin, and Dietz (1995) discovered that women in their study reported hearing disparaging comments about female students from professors, something that the authors interpreted as contributing to the lower levels of self-confidence experienced by the women engineering students. Women in S&E classrooms often report feeling uncomfortable asking questions in class (Brainard, Metz, & Gillmore, 1999; Henes, Bland, Darby, & McDonald, 1995; Landry, 2003). This appears to be especially true for women in engineering classes where they may comprise less than ten percent of the students in the course. When working in mixed gender groups in the classroom, women are interrupted more than their male peers, and their contributions to the group are more likely to be ignored or discounted (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). In an ethnographic study where she observed a second-semester sophomore engineering design course and interviewed students and faculty, Tonso (1996) found that classroom discourse among the heavily male-dominated classroom tended to marginalize women. The male professor for the course tended to dominate over the two female co-instructors and used male-oriented examples and metaphors in his presentations and interactions with students. Male students used profanity and made sexual innuendos that made female students uncomfortable. When student work teams were more weighted with males over females, female input was discounted and female team members treated poorly by their male peers. McLoughlin (2005) refers to these behaviors as

"spotlighting" which she defines as "singling out of women by gender in ways that make them uncomfortable" (p. 373).

Interestingly, in interviews with women who related tales of overt and subtle discrimination in the science classroom, many said that such behavior only served to reinforce their determination to succeed (Seymour & Hewitt, 1997). For others, although not the primary reason for leaving, it was enough to reinforce other reasons for switching. Women who develop good coping skills including the ability to be assertive and persistent in asking faculty for what they need tend to have a higher chance of persisting in S&E programs (Seymour & Hewitt, 1997).

External Sources of Support

The support of peers offers great benefits to undergraduate women in the sciences and is often a factor in persistence (Astin & Astin, 1992). Women often reject the competitive atmosphere of engineering programs in particular and seek out peer support at a higher level than male students (Goodman Research Group, 2002). Female students report participating in study groups in S&E programs more frequently than do men (Brainard, Metz, & Gillmore, 1999; Seymour & Hewitt, 1997). Many female engineering students benefit from participation in professional societies such as the Society of Women Engineers (SWE) where they can find role models in female faculty, have access to networking opportunities for jobs and internships, and experience an environment where they are no longer the minority (Brainard & Carlin, 1998; Brainard, Metz, & Gillmore, 1999; Thompson, 2003).

Summary

As described, there are many factors that influence retention and successful completion of S&E majors for female students. Factors that tend to negatively affect women include poor interactions and sexist behavior in male peers and faculty, lack of self-confidence in a male-dominated field, and loss of interest in engineering stemming from inappropriate choice of career or lack of social relevance in the work world. Factors supporting women include relationships with peers and family. The importance of some of these factors, such as positive relationships with faculty, perceived social relevance of the field of study and maintained interest in the discipline are also important when

examining retention of students of color in S&E programs. These and other factors unique to students of color will be discussed in the following section of the literature review.

Factors Influencing Persistence of Minorities in S&E

Introduction

While all minority groups should not be painted with the same brush when examining factors that influence persistence in S&E degree programs, research does support some commonalities as well as differences between and within racial/ethnic groups for staying or leaving the sciences. Factors affecting social and academic integration of minority students are many and will be discussed in the following sections of the literature review.

Inappropriate Choice of S&E

Seymour and Hewitt (1997) found that minorities more than whites chose SME disciplines because they were encouraged to do so through the active influence of others. Ninety-four percent of all students of color mentioned inappropriate choice as a problem, and 34.6% cited it as a direct reason for switching. Seymour and Hewitt found this to be one of the strongest overall differences between white and non-white SME students. When interviewed, many students of color cited active recruitment efforts by colleges and universities, including offers of scholarships, as motivating factors in choosing to enter SME degrees. Family and community pressures to choose SME careers influenced the decisions of many students in the Seymour and Hewitt study. For example, Hispanic students reported that in their communities, engineering was associated with success and a secure future, and therefore encouraged as a career choice by family members. Once enrolled, many of these students lacked sufficient interest, preparation or understanding of the field to persist. These results suggest that the active efforts to increase minorities in S&E fields, while successful in increasing numbers of entering students, failed to take into account factors affecting persistence once these students were enrolled.

Pre-college Preparation

Inadequate preparation is a common theme in studies examining success and failure of minorities to persist in higher education in general and S&E programs

specifically (Seymour & Hewitt, 1997; Wilson, 2000). Two of the most significant barriers to minority success in S&E degree programs are interrelated: low achievement in mathematics and science, and poor academic preparation in high schools. Seymour and Hewitt (1997) found that 25% of students of color (compared to 10.7% of white students) cited inadequate high school preparation as a factor in switching out of science, math and engineering majors and that 30.8% of students of color (compared to 5.3% of whites) cited conceptual difficulties in science, math, and engineering classes as a reason for switching. In addition, many minority students reported that they had been outstanding students in their high schools and were shocked to find themselves under-prepared to survive in the competitive college science and math environment.

For Native American students there is a paucity of research specifically examining influences on success in science and engineering degree programs. The few studies related to retention in higher education support the idea that lack of pre-college preparation has a significant negative influence on retention of Native Americans. Falk and Aitken (1984) conducted a study where 125 Native American students were interviewed to gain information on, among other things, their perceptions of their own academic preparation for college. Interviews were conducted by trained Native American interviewers and it was found that 76% of the students considered themselves inadequately prepared academically for college. The Falk and Aitken study was not limited to students in S&E degrees and in addition, only involved students who were members of the Minnesota Chippewa tribe. Subsequent studies involving Native American students and academic preparation point to the lack of pre-college preparation as a barrier to success at the university level (Jenkins, 1999; Minner, 1995). It is clear that more research on barriers to success for Native American students is needed to determine whether lack of academic preparation is a dominant factor influencing students to leave S&E majors. The present evaluation study may serve to shed light on this aspect of Native American retention.

For Hispanic students, lack of pre-college preparation is also reported to be a major influence on retention in higher education SME programs. In a study where she conducted in-depth interviews with 22 Hispanic college students at a southwestern university who were *successfully* majoring in science or engineering, Brown (2002)

found that 19 of them had taken honors courses in their high schools. Students revealed that not only did the advanced classes offer them stronger pre-college academic skills, but they also served to increase the students' feelings of self-efficacy with respect to their ability to succeed in college S&E programs.

High pre-college academic achievement has been shown to be positively associated with persistence in S&E degree programs for all students (Bonous-Hammarth, 2000). The performance gap between minority and white students has been of concern for many decades. Results of the National Assessment of Educational Progress (NAEP 2000) continue to show an achievement gap between students of color and white students. On the twelfth grade NEAP assessment for science achievement, 78% of Black, 70% of Hispanic, and 56% of American Indian students scored at the Below Basic level of proficiency. For mathematics, the picture was only slightly less alarming. Sixty-nine percent of Black, 56% of Hispanic and 43% of American Indian students were Below Basic in mathematics achievement (National Center for Education Statistics, 2000b). These students face serious academic challenges when enrolled in degree programs in the quantitative fields of math and science.

A contributing factor to lower achievement for minority students is the so-called "resource gap" that exists between poorer schools and those attended by higher income students. Minority college students are more likely than white students to come from low-income backgrounds and to be educated in schools that have limited resources (May & Chubin, 2003). Limited resources often translate into teachers who are underprepared to teach mathematics and science courses and/or lack of available advanced course work in those subjects. Lower-income schools and rural schools have a higher percentage of teachers teaching out of their primary subject area (Clark, 1999). Weglinsky (2000) found that for 8th grade students, having a teacher with a major or a minor in mathematics or science was related to higher math and science scores on the NAEP. Included in the results of the study described earlier, Adelman (1999) found a high school curriculum of high academic intensity and quality to be the strongest predictor of degree completion at the baccalaureate level, even over such factors as high school GPA/class rank or test scores. This effect was especially true for African American and Hispanic students.

Lack of access to advanced math and science courses often disproportionately affects minority students. For example, when examining trends in course-taking over the last three decades, white students are almost twice as likely as Hispanic students and four times as likely as African American students to take high school courses in precalculus and calculus (Campbell, Hombo, & Mazzeo, 2000). Because of this, many minority students enrolling in university S&E degree programs (especially in engineering) find themselves grossly under-prepared to begin course work in their degrees and often spend the first year in remedial mathematics courses. This trend can often lead to discouragement and switching out of S&E degrees to programs that do not require high levels of mathematics and science skills.

The present evaluation study will inform on issues related to minority persistence specifically in engineering and engineering-related degrees. As such, one aspect of the study will be to explore the perceptions of Native American and Hispanic students on their preparation to enter the degree programs at this university.

Conflicting Cultural Values

Students from other than the majority white culture often find that values inherent in their culture are in conflict with the competitive environment of S&E academic programs. Seymour and Hewitt (1997) stated:

The cultural values and socialization patterns of particular racial and ethnic groups can have negative consequences for the success of their members in S.M.E majors. This is not to impugn such values. However, to succeed in S.M.E careers, male students of color and all women often find it necessary to alter or over-ride important personal values. Those unable to discard cultural values which hinder individual success are vulnerable either to changing majors or to abandoning the attempt to attain any degree. (p. 330)

For Native American students coming from traditional reservation backgrounds, there can be a culture shock that is experienced when making the transition to a predominately white college or university. Native American students report feeling that they are receiving conflicting messages from family and friends to on the one hand, leave the reservation and be successful, and on the other to maintain their traditional connection to tribe and culture (Jackson & Smith, 2001). Once enrolled in college, traditional

Native American students find themselves faced with different norms than those of their culture. Where non-Native children are taught to be active participants in discussion, Native Americans are taught to be active listeners (Rodriquez, 1997). Native American and Hispanic students are less likely than white or black students to question professors about their grades (Seymour & Hewitt, 1997). Asking questions of professors may be equated with questioning an elder, something that is frowned upon in Native American cultures (Yurkovich, 2001). Seymour and Hewitt (1997) attributed these cultural restraints on self-assertive behavior in part to socialized fear of authority based on past oppression of these sub-groups.

The expectations for being assertive and competitive in science and math classes may hinder students who are socialized with more collaborative social norms (Seymour & Hewitt, 1997). In discussing factors that affect Native American college student retention, Tierney (1995) stated: "Good practice encourages cooperation among students, rather than competition. Although such a finding may seem matter-of-fact to tribal people, the norm in Anglo classrooms is often the reverse" (p.5). He suggested that faculty truly committed to diversity in the classroom containing Native American students need to develop ways to create and maintain a cooperative learning environment, a sentiment echoed by others as key to crossing racial and ethnic barriers in the university (Hurtado, Milem, Clayton-Pederson, & Allen, 1998).

Studies aimed at examining how cultural norms and values affect Native American, Hispanic, and African American students in the sciences are limited. Studies that allow for an in-depth look at Native Americans in S&E fields are particularly rare. The current study will pay special consideration to how culture, community, and tradition influence the persistence of minorities in engineering degrees and at examining how these influences affect the academic and social integration of these students into the culture of the university and the culture of science.

Obligations to Family

A common theme to emerge in Seymour and Hewitt's interviews with students of color was the difficulty in balancing family and academic responsibilities. Hispanic, Native American, and African American students discussed needing to return home for kin celebrations or in response to "crises" such as ill grandparents. When interviewed,

Navajo postsecondary students have expressed feeling pressured to return home if conflicts arose in their families, even if those conflicts did not directly involve them and would leave school during the academic year if they felt that family needed them (Jackson & Smith, 2001; Minner, 1995). While not exclusive to S&E students, these cultural pressures that are different from those of the white majority may prove to be barriers to students in disciplines like engineering where course work is demanding and class attendance paramount to success. This is one aspect of the present dissertation study that will be examined.

Family obligations may also include making regular financial contributions to extended family or dependent children while attending school (Corrigan, 2003). For inner-city Black students and Hispanics, these financial obligations coupled with insufficient funding for low-income students create a significant barrier to continuing studies in S&E. Many Hispanic, African American, and Native American switchers out of S&E expressed relief at being able to work and maintain good grades in less academically demanding majors (Seymour & Hewitt, 1997).

Financial Resources

As previously indicated, many students of color face financial barriers to completion of their college degrees. Even for those students who are not supporting families, many have inadequate access to funds to support a college education. Lack of financial resources has often been cited as a barrier to persistence for Hispanic students, (Barton, 2003; Fry, 2003; Lane, 2001), Native American students (Falk & Aitken, 1984; Jackson & Smith, 2001; Minner, 1995), and African American students (National Center for Education Statistics, 2000a; Seymour & Hewitt, 1997). St. John and Noell (1989) found that all forms of financial aid had a stronger impact on access to higher education for minority students than for white students. This included access to scholarships, grants and loans, and college work-study. Due to this, the National Action Council for Minorities in Engineering (NACME) has identified access to financial aid as being a key factor in addressing the problem of minority attrition in engineering degree programs (Georges, 1996).

Isolation and Perceptions of Discrimination

Feelings of isolation have been found to be a factor in attrition from S&E degree programs for minority students (Seymour & Hewitt, 1997; Wilson, 2000). As with female students in the sciences, minority students are often in classes and degree programs where the other students are predominately white males. Minority students are often hard pressed to find faculty mentors that are members of minority groups to serve as role models for them, an important factor in retention (Tierney, 1995). Feelings of isolation increase the likelihood of students leaving a major and are especially intense for students who come from communities that are homogenous with respect to racial makeup (for example, Native American students raised and educated on the reservation) (Seymour & Hewitt, 1997). Related to being a minority among the dominant majority are feelings of overt and covert racism, not unlike what women experience in some S&E majors as gender discrimination. In some cases, overt hostility toward minority students is perceived (Jenkins, 1999; Seymour & Hewitt, 1997) and in other cases the discrimination is more subtle. For example, minority students have expressed the feeling that faculty have lower expectations of them (May & Chubin, 2003; Seymour & Hewitt, 1997) which can lead to self-fulfilling prophecy of failure and attrition from S&E majors. Treisman (1992) found when surveying over 1000 SME faculty, there was indeed the perception that students of color were at greater risk of leaving their major than were white students due to a "motivation gap." This argument posited that if only students of color were more motivated, they would succeed at the same levels as majority students.

Triesman noted that this view as well as others held by survey respondents as reasons for minority student failure, (i.e. lack of family support for higher education, income discrepancies, and poor preparation) put the responsibility for minority student dropout beyond the control of the professor and the university. As he put it, the faculty members were essentially saying, "It's not our fault." This view lends support to the idea that while faculty may not be overtly discriminatory in their behavior toward minority students, their inherent beliefs about these students may well influence how they interact with them.

Exaggerated attention may be paid to minority students who are poorly represented in college classrooms. Tokenism or the expectation that minority students

should be spokespersons for their racial/ethnic group is a more subtle form of discrimination that can lead to exaggerated group differences and increased feelings of isolation (Hurtado, Milem, Clayton-Pederson, & Allen, 1998; Rodriquez, 1997; Seymour & Hewitt, 1997).

When students can overcome feelings of isolation, they increase their chances of successfully completing degree programs. Successful minority students seek out peer support for academic and emotional gain by forming study groups or social circles where they can lessen feelings of isolation. These support structures are often a good substitute for the emotional support that would be provided by family in their home environment (Yurkovich, 2001). Many S&E minority retention programs, including MEPs, put an emphasis on clustering minorities in core degree classes to allow for greater representation and lessen feelings of isolation to aid in overcoming the isolation that can result from being in fields where they are underrepresented (Collea, 1990).

Quality of Instruction and Interactions with Faculty

Looking back to the Tinto (1975) and Bean and Metzner (1985) models of retention discussed earlier in this literature review, interactions with faculty play an integral role in academic integration and commitment to both an institution and to degree completion. Interactions with faculty both in and out of the classroom shape the way students view themselves and the discipline they are studying.

The highest level of exposure to faculty that students have is in the classroom. Seymour and Hewitt (1997) found that poor teaching and inadequate advising were among the most offered factors for switching decisions of students in their study. One third of the students in their study cited poor teaching as contributing to their decisions to leave S&E and a quarter of students cited inadequate advising as influencing their switching decision. Minority students did not cite poor teaching as often as white students as a direct reason for switching. Yet, as mentioned previously, with cultural norms that are often opposed to questioning those in authority, it may not be surprising that this is the case.

Tobias (1990) conducted an ethnographic research study where she examined what she referred to as the "second tier," i.e., students who were capable academically and intellectually to succeed in the sciences, but chose not to. In this often-cited study,

several students who fit the description of second tier students, successful graduates of non-science degree programs, were asked to "seriously audit" introductory undergraduate science courses participating fully in the work of the course. These students took field notes on their experiences and were asked to attend to aspects of the courses that would make science "hard" or alienating to students. What emerged from the study was a picture of introductory science classes that emphasized acquisition of factual information, lack of opportunity for creative thought, and concepts taught in absence of context or application to the real world. The participant-observers in the study saw the competitive structure of science classrooms as creating a culture of student isolation and an absence of a sense of community among learners. Tobias asserted that while science faculty tended to blame the shortfall of undergraduate science students on factors beyond their control (e.g., grade school curriculum and pedagogy), in actual fact it was likely that their own curricula and pedagogy were contributing to a loss of students who could have succeeded in the sciences.

Poor interactions with faculty appear to be particularly common in engineering degree programs. Grandy (1994) found that quality of instruction and relationships with instructors were rated lowest by engineering students of all science and mathematics students surveyed in their study. Astin and Astin (1992) found that for engineering students (in contrast to all other science and math disciplines) higher levels of faculty interaction in and out of the classroom had a *negative* effect on persistence:

Students in engineering programs tend to be less satisfied with their faculty and less satisfied with the quality of instruction than are students in other majors. Thus, the greater interaction with faculty may not have the same positive effect on engineering students simply because these interactions are less likely to be perceived as favorable. (p. 4-28)

The previously cited studies do not specifically examine how classroom culture and pedagogy influence minority students in persisting in engineering and engineering-related degree programs. The present study will seek to illuminate on how these factors may affect minority students at SPU.

Summary

Studies have identified several factors that influence persistence of minority students in higher education and in S&E degree programs. Factors including poor precollege preparation, inappropriate choice of major, cultural issues, lack of financial support, poor teaching, and perceptions of racism and isolation all may interact to affect whether students stay or leave chosen institutions and degrees. The present study will examine more specifically how these factors and others affect minorities at Southwestern Public University and to evaluate the strengths and weaknesses of a program intended to overcome many of the previously mentioned barriers to persistence to students in engineering programs. This study can serve to add to the slim body of research that specifically studies persistence of Native American students in the sciences.

Supporting Minority Student Retention Overview

Retaining students of color can be enhanced by certain types of support activities. Many of these activities and services can be tied directly back to the models and theories related to student retention discussed earlier in this literature review, i.e., increasing academic and social integration as well as student involvement.

Minority students who have been actively recruited by colleges and universities can feel abandoned when they arrive on campus and find there are no services or strategies aimed at increasing their success to completion (Seymour & Hewitt, 1997). There are many strategies that have been proven successful in helping to retain students of color in S&E and other degree programs. Access to scholarships as opposed to loans is a significant way to address the financial barriers faced by minority students (May & Chubin, 2003). Having faculty members who are dedicated to increasing the success of minority students and are actively involved in mentoring them helps to integrate the student into the life of the university and increases chances of degree completion (Quality Education for Minorities Network, 1997). Access to undergraduate research opportunities or other co-curricular activities increase the student's level of involvement, increase interest in the discipline, build self-efficacy, and subsequently help to retain students (May & Chubin, 2003; Seymour & Hewitt, 1997; Tierney, 1995; Windham,

1999). And finally, offering support in the form of structured study groups, study centers, tutoring, and bridge programs prior to enrollment all increase the minority student's chances to be successful academically and therefore increase the probability that they will retained in the major. Many of these support structures are offered at universities around the country in the form of Minority Engineering Programs. A look at the history and influence of Minority Engineering Programs follows.

Minority Engineering Programs

In 1974, the Alfred P. Sloan Foundation published a report serving as a call to action to increase minorities in engineering careers. As a result, the National Academy of Engineering (NAE) established a Committee on Minorities which led to the formation of the National Advisory Council on Minorities in Engineering (NACME) (Collea, 1990). NACME members consisted of top-level industry executives who agreed to provide funding and leadership for efforts to increase minorities in engineering. Among their efforts was the creation in 1980-1981 of Minority Engineering Programs (MEP) at eleven universities nationwide (National Advisory Council on Minorities in Engineering, 2005). Currently, Minority Engineering Programs exist at more than 100 universities nationwide.

Minority Engineering Programs have as their core function to provide a supportive academic community and to facilitate students' personal and professional growth (Landis, 1988). In a mixed methods study involving statistical analysis of institutional data from 338 schools with engineering degree programs, coupled with interviews with deans or their representatives, Morrison, Griffin, and Marcotullio (1995) found that schools successful at graduating significant numbers of minority engineers had MEP that were designed to foster academic excellence and a sense of community among students. Most successful were programs that were adequately staffed and funded in large part as line items in the university budget. In other words, these schools had support above and beyond the scope of the engineering departments at the institution.

Common elements to MEPs nationwide are summer bridge opportunities, clustering of students in core engineering classes, formal freshmen orientation courses, scholarship opportunities, tutoring, and academic and personal counseling services (Collea, 1990). Where MEPs have had strong institutional commitment, as in the case of

California MEPs at UC Berkeley and California State University at Northridge, studies have shown that African American and Hispanic MEP students were retained at rates that were not only higher than their non-MEP minority peers, but higher than engineering students overall (Landis, 1988). The programs at UC Berkeley and CSU Northridge have the components mentioned above and also include close monitoring of student progress and supplemental instruction.

Morrison, Griffin, and Marcotullio (1995) looked at schools that were successful at graduating minority engineers. These authors found that a critical aspect of successful programs were MEPs that offered opportunities for students to become involved before entrance to college, such as summer bridge programs for high schools students and incoming freshmen. Fisher (1984) conducted a study comparing the effectiveness of two types of MEP pre-college engineering programs: one that emphasized field-based, handson activities for students and one that was campus-based and included formal lectures and discussions. Program effectiveness was measured by scores on four sub-tests of a standardized instrument: verbal, science, mathematics, and mechanical comprehension. A control group of students that had not participated in either pre-college program was included for comparison. The results of the study indicate that pre-college MEPs that emphasize technical know-how through hands-on field based activities and applications were more effective in increasing student knowledge and skills. The MEP at SPU offers a summer bridge program that is a mix of traditional academic course work and opportunities for field-based studies with engineering professors. Part of what will be evaluated in the present study is student perception of how these types of activities influenced their academic achievement and retention in degree programs.

Summary

Minority Engineering Programs share a common goal of increasing minority student success in engineering degree programs. Most MEPs share common features including summer bridge programs, tutoring, mentoring, advising, and peer support. Few studies have looked at the effectiveness of MEPs, although there is some evidence for increased retention of students who participate in MEPs. There is evidence that some

forms of support are more effective for students, including opportunities for applied, hands-on training experiences.

The following section of the literature review will begin by examining the field of educational program evaluation. It will include an overview of evaluation as a process and a product, and continue with a discussion of the emerging paradigm of cultural competence in educational evaluation. This section of the literature review will end with an examination of previous evaluation work and its application to the evaluation of MEPs.

Evaluation

Evaluation as Process and Product

A commonly accepted definition of evaluation is "to determine the worth, merit or value of something" often referred to as the evaluand (Scriven, 1967). In more recent work, Scriven (1991) enhanced this definition by pointing out the two facets of evaluation (process and product): "Evaluation is the *process* of determining the merit, worth and value of things, and evaluations are the *products* of that process" (p.1, emphasis added). Evaluation, therefore, encompasses the methodology involved in the study and the outcome of the study itself. In the above definition, *merit* refers to the intrinsic value of the evaluand while *worth* refers to the value participants are getting from the program or product (Davidson, 2005). Merit may be measured in absolute terms, i.e. how good or effective something is, or in relative terms, i.e., how good the evaluand is relative to other programs/products of its kind.

Where evaluation becomes controversial is in the "valuing" part of the accepted definition. The incorporation of values is essentially how evaluation differs from other forms of educational or social sciences research. Values enter into evaluation as a means for decision-making. This differs from the ultimate outcome of educational research:

It is imperative for the evaluator to establish how worthwhile an educational phenomenon is in order to help make decisions regarding what should be done about it. Researchers, on the other hand, search for scientific truth without any desire to attach estimates of worth to their findings. (Popham, 1988)

Patton (2002) described the differences between evaluation and other forms of social science research by placing them on a theory to action continuum. In this view, basic research is "knowledge for knowledge sake" and may generate theoretical underpinnings that, in-turn, inform program design. Evaluations are at the action end of the continuum, in that they are designed to make judgmental claims about programs in operation, with the ultimate outcome being information for decision-making purposes.

Evaluation and basic research in the social sciences are connected in that evaluation uses applied social sciences research methodologies to reach an evaluative conclusion (Scriven, 2004). Mathison (2005) explained that some members in the field of evaluation believe that the job of the evaluator is to collect data and present findings by way of description and explanation without attaching value to the findings, while others see this as falling short of the true work of evaluation. House and Howe (1999) contended that evaluative statements and claims "consist of fact and value claims intertwined, melded together" (p. xv). The work of the evaluator in this view involves a value judgment about the thing being evaluated.

When assigning value, merit, or significance to an evaluand, the evaluator does not operate in a knowledge-free environment. Evaluative claims are based not on the personal preference of the evaluator but on the collection of appropriate data from the program and stakeholders under study. If all relevant interests are represented in the work of the evaluation, the evaluation will be impartial and therefore credible (House, 1980). The making of evaluative claims is intended to facilitate decision-making about the evaluand and therefore be of use to the stakeholders. It has often been the case that evaluations are commissioned to meet some requirement of funding agencies or other such stakeholders of programs. Evaluation results often go unread or shelved and brought out only to show that the requirement was met. Patton (1997) argued for "utilization-focused evaluation." He stressed that evaluation:

Begins with the premise that evaluations should be judged by their utility and actual use; therefore, evaluators should facilitate the evaluation process and design any evaluation with careful consideration of how everything that is done, from beginning to end, will affect use. (p.20)

Utilization-focused evaluation operates under the premise that the evaluation results will be used in the process of program improvement and decision-making, having taken into account the impact of the program on all who receive its services. The results of the MEP evaluation study will be shared with those making program decisions in the hopes of supplying useful data upon which to base decisions.

Scriven (2004) identified nine divisions of evaluation which include program evaluation, product evaluation, personnel evaluation, policy studies evaluation, proposal evaluation, performance evaluation, portfolio evaluation, intra-disciplinary evaluation, and meta-evaluation. This dissertation study is a program evaluation. Worthen, Sanders, and Fitzpatrick (1997) defined a program as "a complex of people, organization, management, and resources that collectively make up a continuing endeavor to reach some particular educational, social, or commercial goal" (p.57). More specifically this study can be referred to as a component evaluation (Davidson, 2005) in that several components of the Multicultural Engineering Program aimed at supporting minority students will be examined to determine overall quality of support for underrepresented student retention. In addition, it is believed that factors external to the MEP that serve to support or hinder minority student persistence will be uncovered through the work of the study.

The evaluation proposed in this study is intended to be a formative evaluation. Formative evaluations are done with the purpose of improving programs (Scriven, 1967). Formative evaluations can give stakeholders useful information about the aspects of a program that are working well or not working well. They can provide information about the perceptions of the intended program audience as to the program's effectiveness, so that decisions can be made about program activities that are based on authentic and accurate data rather than on the assumptions of the program planners.

Culturally Responsive Evaluation

Since the focus of this evaluation study is on underrepresented students in engineering, particular attention will be paid to cultural competence in the evaluation design. Culture can be defined as "a cumulative body of learned and shared behavior, values, customs, and beliefs common to a particular group or society" (Frierson, Hood, & Hughes, 2002, p. 63). SenGupta, Hopson, and Thompson-Robinson (2004) asserted that

the common thread between culture and evaluation is the concept of values. In their words: "Culture shapes values, beliefs, and worldviews. Evaluation is fundamentally an endeavor of determining values, merit, and worth" (p.6). In a discussion on conducting culturally responsive evaluations, Frierson, et al. (2002) asserted that all stages of the evaluation, from design through data analysis, must use culture as a lens through which to examine connections between and among program activities. These authors stated that evaluations that are not culturally responsive run the risk of ignoring or misinterpreting meaning that is based on largely unwritten rules of cultural discourse. While it is not always practical or possible to employ multiethnic teams of evaluators to conduct a program evaluation, "at the very least an evaluator or evaluation team should be fully aware of and responsive to the participants' and stakeholders' culture, particularly as it relates to and influences the program" (Frierson, Hood, & Hughes, 2002, p. 65).

In earlier work on multicultural validity in evaluation, Kirkhart (1995) referred to the need for evaluators to be "culturally sophisticated." In her words:

Lack of cultural sophistication is a threat that crosses validity categories insofar as it diminishes interpersonal validity (restricting the interpersonal connections of the evaluator), consequential validity (failing to conceptualize and facilitate culturally congruent change), and methodological validity (making inappropriate cultural assumptions in the design and implementation of the evaluation). (p. 7)

To be valid, educational evaluation must address issues relating to the influence of cultural context on the settings in which the evaluations occur. Mathison (2005) stated that "evaluators capable of being responsive to the cultural context of the project increase the likelihood that accurate perspectives of participants will be recorded, particularly when qualitative data are collected through interviews and focus groups" (p. 98).

House (1993; House & Howe, 2000), a proponent of deliberative democratic evaluation, discussed the need for the evaluator to be mindful of power imbalances that may be operating in programs involving minorities or persons from low income backgrounds. In this view, the evaluator's responsibilities include determining whether any such inequalities or imbalances are operating with respect to a program's activities and operations. Key to this is ensuring that all relevant interests are represented in the

evaluation process and in the reporting of findings. In explaining the relationship of values to the deliberative democratic process, House and Howe (2000) wrote:

Evaluation is a procedure for determining values, which are emergent and transformed through deliberative processes into evaluation findings. Evaluation thus serves a deliberative democracy, one in which interests and values are rationally determined; and careful discussion and determination require the expertise of evaluators, often acting as experts with special knowledge. (p. 8).

Defining the views, perspectives and contextual issues of minority groups is essential to the evaluation of the MEP and the evaluator has "an obligation to give them special consideration" (House, 1993, p. xv). If the cultural contexts that influence underrepresented student retention are ignored or overlooked in a study such as this, threats would be posed as to the validity of the evaluative claims made.

Evaluation of Engineering Education Programs

The program being evaluated in this study is the Multicultural Engineering Program at SPU. This program has as its core goal the support of minority students in engineering and engineering-related degrees to increase the retention of these underrepresented students. Evaluating what factors contribute to retention of college students has been referred to as evaluating "moving targets" (Hossler, 1991). By that the author meant that determining just what components of a program or what external factors contribute to student persistence is complex and ascribing increases in retention to any one factor is difficult at best and misguided at worst. As the examination of the Tinto, Bean, and Metzner, and Astin theories has shown, persistence is most likely related to a web of interacting variables, some of which have been described in the previous review in greater depth.

Evaluating Support Programs for Underrepresented Students in Engineering
While evaluations of MEPs may be happening within universities in the U.S.,
very little has been published in the literature related to MEP evaluation. One study was
found that involved a research group conducting a mixed-methods evaluation of the
MESA/MEP at American River College in California (Lee, Brazil, Zavalia, & Jones,
1990). Evaluators examined the program as part of a formative evaluation aimed at

program improvement, much as the present study of the MEP at SPU is intended. Data collected included descriptive data, demographics of participants, student evaluations of MEP activities, focus group and individual interviews with students, and staff interviews. Evaluators found that retention rates from first to second semesters for new freshmen in two MEP cohorts were higher than the overall retention rates for the university. From interviews with students and student ratings of MEP activities, the evaluators found that for this particular MEP, students were most benefited by MEP components that offered academic guidance and provided emotional support and opportunities for peer group interactions. They concluded that the program was understaffed and that a full-time director was needed as well as an advisory board including academic deans and industry representatives. They also recommended development of a mentoring component of the program to increase student opportunities for peer group interactions. The intent of the MESA/MEP evaluation was similar to that of the MEP evaluation in this study in that it was not intended to make judgments as to whether the program should continue, but instead was intended to make the types of recommendations that would benefit the functioning of the program.

A second study similar to this dissertation study in methodology and purpose, involving programs specific to women in engineering, was the an evaluation conducted by the Goodman Research Group (2002). The Women's Experiences in College Engineering (WECE) project began as a program evaluation of Women in Engineering (WIE) programs in universities across the United States. WIE programs have been developed at universities across the country to assist in recruiting and retaining women in engineering. WIE programs offer both academic and social support services much like the MEPs do for underrepresented men and women in engineering. These include such activities as mentoring, tutoring, skills workshops, outreach activities, and social opportunities (Goodman Research Group, 2002). The WECE project was funded jointly by NSF and the Alfred P. Sloan Foundation and conducted by the Goodman Research Group, a company specializing in program evaluation. As in the current evaluation of the MEP at SPU, the WECE project's focus broadened to "explore the range of activities and supports for undergraduate women in engineering across all the institutions, both with and without WIE programs" (p.i). The study employed a mixed-methods approach that

included multivariate analysis of the results of student questionnaires, and qualitative analysis of open-ended survey items and focus group discussions. Results of the study were supportive of many of the factors presented as barriers or supports to women in engineering that exist in the scholarly literature. Interestingly, the evaluators found no significant differences in persistence between women at schools with WIE programs and women at non-WIE institutions. They attribute this finding to the fact that many schools without formal WIE programs offered many of the same program elements as WIE schools but these programs were run by other organizations within the engineering schools. Students who took advantage of the support programs offered at both WIE and non-WIE universities had higher levels of persistence.

The present study seeks to "explore the range of activities and supports" (Goodman Research Group, 2002) for undergraduate minorities in engineering as well as evaluating MEP components for effectiveness in retaining these students in their degrees. While this differs from the WECE project evaluation in that the support program is aimed at a different audience, the WECE project can serve as a model upon which to base some of the design and analysis of the present study.

Accreditation of Engineering Degree Programs

While program evaluations such as the MEP evaluation in this study are fairly uncommon, what is most common with respect to engineering education is the evaluation of programs done for accreditation by the Accreditation Board for Engineering and Technology (ABET). ABET oversees the specialized accreditation of programs in engineering, engineering technology, and engineering related fields and is a federation of professional engineering societies that form a board of directors and four working commissions (Aft, 2002). ABET has outlined criteria for assuring quality in engineering education that include the following: student performance, educational objectives, assessment of learning outcomes, professional component, faculty quantity and quality, appropriate facilities, institutional support and specific program criteria (e.g., criteria for mechanical or environmental engineering)(Accreditation Board of Engineering and Technology, 2004). The engineering degree programs encompassed in this study are ABET accredited and, as such, the faculty and staff have been involved in ABET evaluations in the past. Evaluations for accreditation differ in their purpose and scope

from the type of evaluation proposed in this study. The coupling of self-evaluation by the programs staff with external evaluation by other technical experts can be a strong point of accreditation evaluations. There is the assumption in the accreditation process however that only members of the profession are qualified to judge the activities of their peers, an opinion that is not necessarily shared by the education community (House, 1980). There is also the tendency in the accreditation process for the focus to be placed on inputs and processes and not on outcomes (Stufflebeam, 2000). In other words, accrediting bodies may be so focused on whether certain criteria are being met by the program that other useful information concerning process and unintended outcomes may be overlooked or lost in the process. The quality of accreditation teams can be highly variable and dependent on the team members who are often chosen by the institution being evaluated (House, 1980).

The present evaluation of engineering programs differs from the accreditation evaluation process in that it is intended as a formative evaluation of a program designed to support persistence of underrepresented students in their degree programs. Attention to process as well as unintended outcomes of participation in the program can serve to help stakeholders make program-related decisions for improvement of the education of the targeted student population.

Emerging Methodologies for Program Improvement

In recent years articles have been emerging in engineering education journals related to methodologies for doing "in-house" evaluations of engineering programs and academic offerings. Olds and Miller (1998) recently wrote an article for the Journal of Engineering Education meant to help faculty develop assessment plans for their engineering programs that would ultimately help to decide how to best "improve each student's educational experience" (p. 173). These authors likened assessment of engineering programs to the engineering design process that is taught to students over the course of their education:

Engineering design is an iterative, non-linear process beginning with identification of stakeholder (particularly client) needs, followed by detailed development of project goals and objectives, generation of design alternatives, selection of the "best" design that meets project objectives while addressing

anticipated constraints, and communication of results to stakeholders, who in turn provide feedback which is used to refine and improve the final design. (p. 173) Many of the components are parallel: the examination of goals and objectives while attending to constraints and context, communication of results to stakeholders and the use of feedback to improve design. When communicated in this way, engineering faculty can see the value in evaluation of their educational programs.

Other recent publications are meant to offer suggestions for a larger "toolbox" for engineering educators interested in evaluating the success of their programs. Leydens, Moskal, and Pavelich (2004) give a concise but thorough description of how qualitative research methods can be used to assess engineering education. Meant to inform engineers who most often deal in numerical (i.e., quantitative) data, the authors lay a solid case for qualitative and mixed-method approaches to evaluation. Van Aken, Watford, and Medina-Borja (1999) discussed the use of focus groups for minority engineering program assessment. These authors presented the strengths of focus group methods in obtaining student feedback on what is beneficial and what could be improved in the programs designed to increase minority student retention in engineering. The present study, a mixed-methods approach to evaluating persistence factors for underrepresented students in engineering, seeks to add to the body of literature and to the "toolbox" for those seeking to evaluate similar programs at other institutions engaged in science and engineering education.

Summary

Evaluation is a field of research that seeks to uncover the merit and worth of the program being evaluated. Formative evaluations are done with the intent of improving the programs they are studying, by uncovering strengths and weaknesses within the design and delivery of those programs, so that decisions can be made with respect to programmatic activities and future efforts. Particular attention must be paid to cultural competence in evaluations designed to examine programs that serve underrepresented populations.

The previous section of the literature review brings to light the lack of published research directly related to engineering program evaluation that is unrelated to the

accreditation process. It also reveals that there is a limited amount of research related to persistence of women and minority students in engineering degree programs. The present study will seek to inform on both the effectiveness of the MEP activities on student retention, and to uncover other issues that influence minority student retention at Southwestern Public University.

The preceding chapter has examined the scholarly literature related to persistence of minority students in science and engineering and the literature related to educational program evaluation. The following chapter will describe the research methodology including research design, data collection, and data analysis that will guide the present evaluation study.

CHAPTER 3

CONTEXTS OF THE STUDY

Introduction

As put forth in the Program Evaluation Standards (Joint Committee on Standards for Educational Evaluation, 1994), one dimension of accuracy in evaluation is examining the context in which a program exists "in enough detail, so that its likely influences on the program can be identified" (Standard A2). The following chapter is intended to provide a contextual background for the evaluation of support for underrepresented students at Southwestern Public University (SPU). Included is an overview of enrollment and retention for the university and, more specifically, for students enrolled in engineering and engineering-related degree programs. This review is followed by an overview of the engineering degree programs offered at SPU including types of degrees offered and student characteristics. Next, the Multicultural Engineering Program (MEP) will be described including the program components under examination in this study: summer bridge program, tutoring, mentoring, and social support activities. Finally, a description of the Engineering Talent Pipeline project, a five-year grant-funded project to increase recruitment and retention of underrepresented students in engineering will be described along with its relationship to this study.

Context: the University

Enrollment

SPU is a medium-sized Doctoral/Research- Intensive public institution that serves approximately 13,000 students on its main campus. The majority of the students (78%) who attend the university are residents of the state in which it resides. A comparison of the ten year average ethnic/racial make-up of the SPU student body to peer institutions is represented in Table 2. Percentages are based on first-time, full-time (FTFT) freshmen enrollment.

Table 2. Comparison of ethnic make-up of SPU to its peer institutions.

Ethnicity	10 year average for SPU	10 year average for peer institutions
African American	1.6%	8.9%
Asian American	2.0%	5.2%
Hispanic	7.9%	5.0%
Native American	4.5%	0.7%
White	81.8%	80%
Total Diversity	24%	18%

SPU has a higher percentage of Native American and Hispanic students and fewer African American and Asian American students than do its peer institutions. When all undergraduate students (including other than FTFT freshmen) are taken into account, the diversity of the university student population at SPU is 24% and 18% at peer institutions (Task Force on the Freshman Year, 2004). The university demographics are reflective of the state in which it resides where, due to its geographic location, Hispanic and Native Americans are the largest minority groups represented in the population.

Retention

First year retention rates for the university are somewhat lower that those of comparable peer institutions. Overall retention of students from freshman to sophomore year is slightly lower than at peer institutions. Overall retention of FTFT freshmen into their second year of study at SPU averages yearly between 67% and 68%, while rates for peer institutions average in the mid-70% range. In recent years, the university has expended efforts to determine the factors affecting student retention, designating a Task Force on the Freshman Year to explore reasons why students stay or leave the university.

While the university has a larger population of minority students than its peer institutions (Table 2), retaining these students has been problematic. When examining retention rates by racial/ethnic categories, a picture emerges of a university that is retaining white students at a higher than overall rate, while all minority student groups are retained at rates 3-10% lower than the overall retention rate for the university (see Table 3).

Table 3. A comparison of SPU retention rates by ethnicity for the years 1994-2002. Taken from: Task Force on the Freshman Year, 2004

Retention of FTFT	Average Retention by	Difference from Overall
Freshmen at SPU	Category	Average Retention Rate
Overall Average	66.6%	
African American	64.7%	-1.9%
Asian American	61.2%	-5.4%
Hispanic	62.9%	-3.7%
Native American	55.8%	-10.8%
White	68.0%	1.4%

Retention rates for FTFT Native American freshmen are particularly low relative to the overall retention rate at SPU. Low retention of Native American students is of particular concern at the university, and several programs have retention of these students as a mission. There are several university level programs aimed at supporting minority students, and particularly Native American students, including Native American Student Services and the Multicultural Student Center. A brief description of the services of these two programs follows.

University Level Support for Retention of Minorities

One aspect of this study will examine whether underrepresented students in engineering are utilizing university-level support programs in conjunction with or separate from the Multicultural Engineering Program. A university program specifically designed to increase retention and graduation rates of Native American students is Native American Student Services (NASS). NASS provides a place where students can gather to socialize, study, and use computer facilities. Other services include guidance on registration, orientation programs for incoming freshmen, personal counseling, information on scholarships, and information on social services (e.g., child care and housing). NASS serves approximately 125-150 new students each year.

The Multicultural Student Center (MSC) is another university level program offering services to first generation college students, underrepresented students, and students with financial need. MSC coordinates the Successful Transition and Academic Readiness (STAR) program that includes a five week summer bridge program for incoming freshmen. The Multicultural Engineering Program's STAR-PALS (Pathways Leading to Success) summer bridge program is a focused STAR program that will be

discussed in more detail later in this chapter. The STAR summer bridge program serves approximately 125-150 new students each year. MSC also offers peer advising and assistance to clubs and organizations associated with cultural and educational events.

Context: Engineering Programs

Overview

The engineering and engineering-related degree programs in this study were established as part of the College of Engineering and Technology in 1969. In 2004, the university underwent a restructuring that caused the College of Engineering and Technology to be dissolved and the engineering programs to become departments within a College of Engineering and Natural Sciences (CENS). The three engineering departments included in the newly established CENS include the departments of Electrical Engineering, Civil and Environmental Engineering, and Mechanical Engineering. The two engineering-related departments include Computer Science and Engineering, and Construction Management. Within the five departments, six Bachelor of Science degrees are offered in the following disciplines: civil engineering, environmental engineering, electrical engineering, mechanical engineering, computer science, and construction management. The four engineering degree programs and the computer science program are accredited by the Accreditation Board of Engineering and Technology. The Construction Management degree program is accredited by the Accreditation Council for Construction Education. Approximately 40 full-time and 10 part-time faculty members teach classes and conduct applied industrial research in the five departments. Women make up less than 10% of the faculty. Part-time faculty members include local professionals from engineering and construction management companies who are often paired with academic faculty to team teach core design courses in the curricula.

Enrollment

Currently, the total undergraduate enrollment in engineering, construction management, and computer science programs is approximately 750 students. The ten year average ethnic make-up of students specifically enrolled in engineering and engineering-related programs is fairly comparable to that of the overall university (Table

2) except for a slightly higher percentage of Native American students (6.8% compared to 4.5% for the university). Minority composition varies by department with the largest percentage of minority students enrolled in civil and environmental engineering degree programs and the fewest in computer science. Female student enrollment is even smaller than that of minorities with the exception of enrollment in civil and environmental engineering (see Table 4).

Table 4. Average underrepresented student enrollment by department for the years 1999-2005. (Does not include international students).

Department	Minority Enrollment	Female Enrollment
Civil and Environmental Engineering	29.1%	25.6%
Electrical Engineering	20.5%	14.2%
Mechanical Engineering	18%	13.0%
Construction Management	17.8%	13.0%
Computer Science	17.3%	12.8%
Pre-engineering	27.4%	14.1%

Many students who are interested in engineering degree programs are deficient in math courses and begin their freshmen year as pre-engineering students. For spring 2005, 143 of the 815 undergraduate students in engineering and engineering-related degrees were actually pre-engineering students. These are freshmen students who may be at great risk of not being retained if they cannot successfully complete the prerequisite courses prior to declaring a specific engineering major. The average minority composition of the pre-engineering students for the last seven years is 27.4% and the average enrollment for women is 14.1%. With more than a quarter of pre-engineering students being of Asian American, African American, Hispanic, or Native American ethnicity, and women making up so small a proportion it is important to gain an understanding of what factors influence their decisions to continue in a declared engineering major or to switch to another degree program. Gathering this information is an important component of the present study.

Retention

When examining FTFT retention rates for engineering and engineering-related degree programs, a picture begins to emerge that shows attrition of a higher than average number of students regardless of ethnicity. If retention is taken to mean retention at the

university and not necessarily in engineering degrees, averages are lower than the university but not alarmingly so. If retention is examined through the lens of students who began as engineering students and are retained in engineering programs, a more revealing picture emerges. Table 5 shows retention rates of students who began in engineering and engineering-related programs and stayed at SPU (but may have switched out of engineering programs) versus those who began in engineering programs and not only were retained at the university, but were retained by the departments as well.

Table 5. Retention of students at the university and within Engineering (EGR) programs.

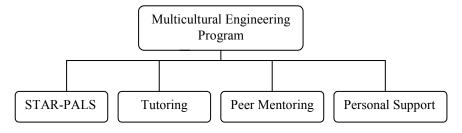
Department	Enrolled in program and were retained at the university (includes those who switched out of EGR)	Enrolled in program and stayed in EGR programs
Civil and Environmental		
Engineering	70.5%	48.6%
Electrical Engineering	61.2%	46.9%
Mechanical Engineering	68.3%	49.4%
Construction Management	59.0%	52.0%
Computer Science	63.4%	39.1%

Retention can be viewed through multiple lenses. For example: students who begin in Civil and Environmental engineering fair better than overall students in terms of retention at the university. From the perspective of the university this could be considered a success, in that some of these students may have found a better "home" in other departments and thus chose to stay at the university. From the perspective of the engineering department, they are losing more than half of their students by the beginning of the second year. The data shown in Table 5 are for all students, minority and non-minority. Retention data are unavailable by gender and ethnicity, but the preceding table paints a picture of programs that face hurdles involving retention for all students. Uncovering factors that influence underrepresented minority students' decisions to remain or leave engineering may prove enlightening to programs that serve them and may provide insight into barriers to persistence of students other than the minority students in this study.

The Evaluand: The Multicultural Engineering Program Overview

The Multicultural Engineering Program (MEP) was established in 1994 to aid underrepresented students in making the transition to university engineering programs and to help sustain them in their efforts toward graduation. The MEP serves not only underrepresented students but also first generation college students who may or may not be underrepresented women or minorities. In the fall of 2002, the MEP served students with an ethnic/racial composition of 4% African American, 21% Hispanic, 39% Native American and 36% Other. MEP activities include the STAR-PALS summer bridge program for students who will be matriculating in the following fall semester. Once students are enrolled and attending classes in the fall, MEP supports them through tutoring, social gatherings, supplemental advising, and through a newly implemented peer mentoring program (See Figure 2). The MEP elements will be described in the following sections.

Figure 2. Elements of the Multicultural Engineering Program



STAR-PALS Summer Bridge Program

The cornerstone of the MEP is the Pathways Leading to Success (PALS) summer bridge program that operates as one of the STAR programs discussed previously. The STAR-PALS summer program is a five week residential program for 15-20 students who will attend the university the following fall semester and who are considering a major in engineering or construction management. These students must also be accepted to the university's Successful Transition and Academic Readiness (STAR) program. STAR-PALS students take two undergraduate summer courses for credit toward their liberal studies requirements. Students are provided with an introduction to the engineering disciplines through hands-on activities with engineering faculty and staff, industry-related field trips, collaborative learning activities, and math readiness/review activities. The

overarching goal of the summer program is to help incoming freshmen establish a support network of faculty, staff, and peers to aid in the transition to university life.

Tutoring

MEP offers tutoring services that are available to all engineering students, not just minority and/or MEP students. Tutoring is available for Introduction to Programming (CS 122), Introduction to Computer Science (CS 126), Electrical Engineering I (EE 188), Applied Mechanics Statics (EGR 251), and Applied Mechanics Dynamics (EGR252) as a means of filling in the gaps for classes not tutored by the university's Learning Assistance Centers. MEP also offers tutoring for pre-Calculus, Calculus I and II, and introductory physics and chemistry courses. If students are in need of assistance for other engineering or engineering-degree related classes, MEP staff contact the course instructor and ask for a recommendation for a tutor for those students.

Peer Mentoring

The MEP peer mentoring program began in the fall of 2003 and since has consisted of 5-8 mentor/mentee pairs. Native American students make up the highest portion of mentees utilizing the program over the past two years. The program pairs summer bridge students with upperclassmen in engineering programs. Pairs meet weekly with the intended outcome being that freshmen/sophomore mentees have someone who has been through the academic and social rigors of the degree programs and can act as a means of emotional and social support. Time spent together may be purely social, as in going to dinner or a movie, or can be related to academics. Each mentor/mentee is paid a stipend of \$200 each if they meet the program requirements.

Additional Services

In addition to the services described previously, the MEP office acts as a place where students can drop by for emotional and social support from program staff. Information is available on scholarships and internships for engineering students. Social gatherings are held twice each semester to encourage participation in MEP activities and to inform students of the services available to them. The MEP director is also directly involved in clubs that are meant to support minority students in engineering such as the Society for Hispanic Professional Engineers, and the American Indian Science and

Engineering Society and uses her involvement as a means to inform students about MEP services.

The Engineering Talent Pipeline Project

In the spring of 2003 the former College of Engineering and Technology was awarded \$1,138,000 by the William and Flora Hewlett Foundation for the Engineering Talent Pipeline (ETP) project. The ETP project is one of nine grant-funded projects awarded to western U.S. universities under the Hewlett Foundation's Engineering Schools of the West Initiative. The grant funds the college for five years (2003-2008) for activities directly related to increasing recruitment and retention of students in the five degree programs with special emphasis on underrepresented women and minorities.

The ETP project is currently in its third year. First year activities included planning, and collection of baseline data on recruitment and retention. Year two activities involved ten sub-projects of varying types and complexities. Third year activities include fifteen sub-projects focused on various strategies for retention and outreach. Years four and five will focus on sustaining and assessing on-going efforts. Enhancement of the Multicultural Engineering Program was specifically noted in the grant and receives a portion of funds for each year of the ETP project. The researcher in this evaluation study has been contracted by the engineering programs to act as a project evaluator for the work of the grant. Results of this evaluation study may help to inform programmatic decisions on expansion or reduction of MEP services.

Summary

In the preceding chapter the contexts of the evaluation study were described. A discussion of university-level enrollment and retention was followed by a discussion of engineering and engineering-related degree enrollment and retention with an emphasis on how these programs compare to the university overall. The chapter continued with a description of the evaluand, the Multicultural Engineering Program, describing the various program components and services offered to students. The chapter concluded with a brief description of a grant-funded project, the Engineering Talent Pipeline, which is providing funds for MEP activities and possible expansion of services. The following

chapter will address methodology for investigating issues related to persistence of underrepresented students, including an evaluation of the MEP as a source of support.

CHAPTER 4

METHODOLOGY

Introduction

In this chapter, the methodological approach to the evaluation of support for women and minorities in engineering and of the Multicultural Engineering Program (MEP) will be presented. The discussion will begin with an overview of the approaches to evaluation that will frame the study including responsive evaluation and the case study approach. This will be followed by a restatement of the research questions, and the data collection and analysis that will be utilized to address those questions. Issues of validity, credibility, and researcher bias will be addressed. Instruments used in the study including interview protocols and the on-line student survey are included as appendices to this document.

Approaches to Evaluation

Participant-oriented Evaluation

As evaluation evolves as a field of study, many practitioners and theorists have attempted to classify approaches to program evaluation. Worthen, Sanders, and Fitzpatrick (1997) identified six alternative evaluation approaches which include objectives-oriented, management-oriented, consumer-oriented, expertise-oriented, adversary-oriented, and participant-oriented. These authors proposed a framework for the evaluator to consider the most useful approach for the program under study by comparing and contrasting the six alternative methods for purpose, characteristics, uses, criteria for judging the evaluations, benefits, and limitations. The evaluator becomes responsible for choosing the evaluation approach that best fits the given situation. The evaluation of the MEP is a participant-oriented evaluation in that it is intended to "direct the attention of the evaluator to the needs of those for whom the evaluation is being done, and it stresses the importance of a broad scope: looking at the program from different viewpoints" (Worthen, Sanders, & Fitzpatrick, 1997, p. 167). Participant-oriented

evaluation approaches emphasize the importance of studying the context within which a program operates and acknowledge the complexities that contextual issues bring to the study.

Responsive Evaluation

As one of the earliest proponents of participant-oriented evaluation approaches, Stake (1975; 1976) argued for evaluations that go beyond examining program goals to incorporating the realities of the program as examined through multiple lenses so that they become *responsive evaluations*:

An educational evaluation is responsive evaluation if it orients more directly to program activities than to program intents, if it responds to audience requirements for information, and if the different value-perspectives of the people at hand are referred to in reporting the success and failure of the program. (Stake, 1975, p. 10) In utilizing a responsive evaluation approach, the evaluator becomes familiar with the program partly through interactions with program staff and other stakeholders and uncovers "issues, or problems or potential problems. These issues are a structure for continuing discussions with clients, staff and audiences and are a structure for the datagathering plan" (Stake, 1975, p. 10). The responsive evaluation approach is highly appropriate to examine the worth and merit of a program designed to support underrepresented minority students because of its attention to "program uniqueness and to the cultural plurality of people" (Mathison, 2005, p. 376).

Responsive evaluations pay particular attention to program activity. By examining what is actually happening in a program as opposed to (or in addition to) what is intended by program planners, a truer judgment of merit and worth may be achieved. Scriven (2004) put forth the view that if the evaluator focuses only on program goals or intents he or she will not be conducting a credible evaluation. In this view, a program may have met its goals, but not necessarily be a good program. For an evaluation to be valid, the evaluator must examine every dimension that the program is affecting, and include side effects and unintended effects when judging merit and worth. The evaluator must consider the processes involved in meeting program goals to judge whether they are ethical and not in violation of standards. Scriven (2004) asserted that what a program is

and does is tied to the values that are uncovered in the course of the evaluation, and in turn leads to understanding the significance of the program for the stakeholders involved.

Case Study Evaluation

Stake became a proponent of a case study approach to evaluations that are considered responsive (Mathison, 2005). Stufflebeam (2000) included the case study approach as one of 22 evaluation approaches in use by evaluators. A case study approach to program evaluation involves delving deeply into description and analysis of a particular program or object. As in both the ideas of participant-oriented evaluation and Stake's responsive evaluation approaches, case study evaluations are focused on the main issues of concern to the evaluation's key stakeholders. Stufflebeam (2000) described the appropriateness of case study approaches to evaluation as follows:

Case study requires no controls of treatments and subjects and looks at programs as they naturally occur and evolve. It addresses accuracy issues by employing and triangulating multiple perspectives, methods and information sources.... It looks at the program holistically and in depth. It examines the program's internal workings and how it produces outcomes. (p.55)

Yin (2002) described three purposes of case study research: exploratory, descriptive, or explanatory, and examined their applications in evaluation research. Exploratory case studies may be used to explore the possible outcomes a program or intervention when those outcomes are not clearly defined or understood. Descriptive case studies may be useful in describing the evaluand in the real-life context in which it occurred when it is necessary to have a fuller, richer understanding of the program. Explanatory case studies are useful in explaining the complex causal links between interventions and program outcomes. The evaluation of the MEP and engineering support for women and minorities can be viewed as an explanatory case study in that it will be done with the intention of determining the evaluand's effects on the retention of minority students. The evaluation will seek to explore the relationship between participation in program activities and persistence in engineering degree programs.

The evaluation of the MEP and support for underrepresented engineering students will be framed by the preceding approaches to evaluation. It will examine a single program in-depth, going beyond intended outcomes to uncover unintended antecedents,

transactions, and outcomes, and will be directed by the issues and concerns of the major stakeholders in the program. It is intended to be a responsive evaluation in that the program will be viewed from multiple lenses, and will take into account the differing value-perspectives of those directly involved in the programs' activities, services, and outcomes.

Restatement of the Research Questions

The questions guiding this evaluation study were negotiated with the director of the engineering degree programs, the MEP director, and incorporated feedback from the dean of the College of Engineering and Natural Sciences and faculty members in the engineering and engineering-degree programs (see Appendix A). The research questions are intended to uncover factors affecting the persistence of women and minorities in engineering degree programs, and to examine the MEP as a source of support for underrepresented students in engineering.

- 1. What factors influence retention and graduation of underrepresented women and minority students in engineering and engineering-related degree programs?
 - a. What social integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: peer interactions, faculty interactions, clubs, and competitions.
 - b. What academic integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: quality of instruction, difficulty of courses, and pre-college academic preparation.
 - c. What factors external to the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: cultural, community, and family influences.
- 2. How do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
 - a. How do minority students who utilize MEP components compare academically to minority students who do not utilize MEP components?

- b. How do students who utilize MEP components compare to minority students who do not utilize MEP components in terms of satisfaction with their degree programs?
- 3. Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?
- 4. Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

Population and Sample

The purpose of this study is twofold: to identify factors that support or hinder women and minority students in attaining engineering degrees and to gain insight into the effects of the Multicultural Engineering Program components on the successful retention of underrepresented minority students in engineering and engineering-related degree programs. Stakeholders in the study include: underrepresented women and minority students, MEP staff, and engineering faculty.

From the larger population of all students seeking degrees in engineering or engineering-related degree programs, a sub-sample of all students considered to be underrepresented (of African American, Hispanic, or Native American descent and all female students) was determined through the use of the university's student database. Because the study seeks to inform issues related to the retention of underrepresented students and the MEP under study, purposeful sampling of stakeholders in the evaluation was utilized for the qualitative components of the study (interviews and focus groups). Purposeful sampling "is aimed at insight about the phenomenon, not empirical generalization from a sample to a population" and can therefore provide contextually relevant, rich sources of information to address the research questions in the study (Patton, 2002, p. 40). Purposeful sampling procedures for focus group and individual interviews will be discussed in the following section on data collection and are outlined in Table 6.

For aspects of the study employing statistical research methods to compare academic performance and retention rates for students within and outside of the MEP, all

minority students (MEP and non-MEP) and non-minority students were included in the analyses.

Table 6. Sampling strategies for MEP study components.

Study component	Sampling strategy	Description of Selection Process	
Student Focus	Criterion Sampling	MEP students who:	
groups		1. Are female and/or of African American, Hispanic,	
		or Native American descent	
		2. Have completed at least one engineering-specific	
		course or one semester of pre-engineering	
		coursework	
Individual Student	Stratified	MEP and non-MEP students across three sub-groups:	
interviews	Purposeful	1. Academically excelling- 3.5 GPA or above	
	Sampling	2. Academically average	
		3. Academically struggling – below 2.0 GPA	
Faculty interviews	Criterion Sampling	Faculty who:	
		1. Teach or have taught engineering core courses	
		and/or	
		 Sponsor engineering clubs or research programs for minority students 	
MEP staff	All staff	MEP Director, graduate assistant and student worker	
interviews			
GPA comparisons	Comprehensive	100% MEP minority and first generation engineering	
	sampling	students	
		100% non-MEP minority engineering students	
		100% of non-minority engineering students	

In addition to the above sampling strategies, snowball or chain sampling involves identifying additional cases that may inform the study based on the recommendations of those who have been interviewed, or persons "in the know" (Patton, 2002). During the process of interviewing students and faculty, additional informants with the potential to provide information-rich sources of information were identified and contacted for interviews.

Underrepresented women and minority students currently enrolled in engineering and engineering-degree programs were identified based on the above sampling strategies, through use of the university's student database, student transcripts, and recommendations from the MEP director and engineering faculty. Students were recruited for the study through the help of the MEP director, and engineering faculty and staff and through attendance at MEP and engineering social events, email and follow-up telephone contact. Interviews and focus groups were conducted in locations determined

by the researcher to be easily accessible for the students and private for ease of discussion.

Faculty involved in teaching core courses in the degree curricula, as well as department chairs and the interim director of engineering programs were invited to participate in interviews. In addition, faculty acting as campus advisors to the National Society of Black Engineers (NSBE), American Indian Science and Engineering Society (AISES), and Society for Hispanic Professional Engineers (SHPE) were invited to participate in interviews.

Data Collection

Mixed-Methods Approach

Over the past 30 years, debate over which methods (quantitative or qualitative) should be utilized in evaluations has been mostly resolved by an understanding among evaluators that both types of research methods have their place in evaluation research. Many would now agree that the best evaluations incorporate both qualitative and quantitative data to arrive at a holistic view of a program's effectiveness (Lapan, 2004). Where evaluation results were was once deemed valid only if they involved controlled experimental approaches and testing, many evaluations today are moving towards a mixed-methods approach where qualitative data is used to validate and expand upon quantitative data analysis (Worthen, Sanders, & Fitzpatrick, 1997). The evaluation of support for underrepresented students in engineering degrees and the MEP utilized a mixed-methods approach where data collection methods were driven not by a particular research paradigm, but by choice of methods most appropriate for addressing the research questions in the study. A matrix for the evaluation of support for underrepresented students is attached as Appendix B.

Quantitative Data Components

University Student Database

The university's Peoplesoft student database and student transcripts were accessed to address research questions examining potential differences in academic achievement and retention between ethnic/racial groups, males and females, and between MEP minority students, and non-MEP minority students. Through the university's

student database, engineering student data can be accessed including students' ethnicity, academic plans, academic levels, grade point averages and academic standing (good vs. probation or suspension). The database contained records for all students in engineering and engineering-related degree programs at the undergraduate and graduate level (N=834). For purposes of analysis related to the research questions in this study, the following records were removed before analysis: international students (N = 38), graduate students (N = 15), post-baccalaureate students (N = 12) and students of unreported ethnicity (N = 19). Also removed from the analysis were students who were suspended from their academic programs (N = 42). 750 students remained in the database for analysis. Data were available in Excel files that were imported into SPSS and analyzed with appropriate statistical methods described in the data analysis section of this chapter. Web-based On-line Student Survey

A web-based engineering student survey was developed to gather information on various aspects of the study. The survey was developed by the researcher and the MEP director. Survey items were piloted with five engineering students and three non-engineering students for the purpose of determining face and content validity. In the survey, students were questioned about their knowledge and usage of MEP activities and services, use of campus support programs, their ratings of the importance of various factors in supporting them through their degree programs, and types of support they are not receiving but would like to have. Students were recruited to participate in the survey through email solicitation to an email list of all engineering students (including white, male students). One hundred-thirty students replied to the survey. This constitutes a relatively low response rate of 18% which can lead to error in interpreting implications of survey results (Fowler, 2002). However, triangulation of survey results with student interview data will mitigate this issue. The survey is included as Appendix C.

Qualitative Data Components

Qualitative data collection strategies are intended to allow for deeper and richer examinations of events and phenomena that may come to light through quantitative data analyses. For example, where statistical analyses can determine that minority students are underrepresented in science and engineering programs, interviews and focus groups

of these students can help us to understand the reasons for this lack of representation (Leydens, Moskal, & Pavelich, 2004; VanAken, Watford, & Medina-Borja, 1999).

Interviews and focus groups were conducted with targeted students, faculty, and staff in the engineering programs for in-depth examination of issues affecting student retention as well as effectiveness of the MEP's retention efforts. Institutional Review Board approval was obtained in the fall of 2004. Interview questions were pilot tested with dissertation committee members and fellow graduate students prior to beginning the study. Student interview questions were field-tested with two graduating senior engineering students in the spring of 2005 and resulted in slight alterations in the protocol. Faculty interview questions were piloted with an engineering faculty member in early summer of 2005 and found to be satisfactory. All interviews were audio-taped with a digital voice recorder and then transcribed into text files for analysis. Digital audio files of interviews will be deleted and text files will be destroyed at the end of the study. Interview questions for faculty, staff, and students are attached as Appendices D-G.

Student Focus Groups

Focus groups work well in a study that also involves individual interviews. While individual interviews allow for greater depth of information with a single participant, focus groups allow for group interaction that brings to light similarities and differences in participants' experiences (Morgan, 1997). Criterion sampling involves selecting participants in a study based on predetermined criteria relevant to the study (Patton, 2002). For focus group interviews, students were targeted who were MEP students who were of African American, Hispanic, or Native American descent, and had completed at least one engineering-specific course or one semester of pre-engineering coursework (see Table 6).

It was intended to conduct several student focus groups with MEP student participants. After multiple avenues of recruiting students for focus group participation were attempted, a single focus group of three students was conducted. Focus group participants included two male, first generation freshman students who had participated in the MEP summer bridge program the previous summer, and a female, Native American junior who had recently begun involvement in MEP activities. The focus

group was used to address general issues related to MEP effectiveness, program satisfaction, and to generate concepts and issues related to retention of minority students in engineering degrees.

Individual Student Interviews

Individual student interviews were undertaken to examine issues affecting retention of underrepresented women and minority students and allowed the researcher to explore issues that may be too sensitive to discuss in a group situation. These interviews examined the social and academic integration factors discussed earlier in the literature review including such things as faculty and peer interactions, family influences, and perceptions related to teaching and learning in the degree. Particular attention was paid to those issues related to research questions aimed at understanding cultural and social factors that help or hinder underrepresented students. Individual student interviews were utilized to uncover issues related to retention of all underrepresented engineering students, both MEP and non-MEP, including issues related to persistence of women in engineering degrees.

Stratified purposeful sampling allows for sampling across sub-groups to make comparisons and contrasts (Patton, 2002). For individual interviews, students who are excelling academically, academically-average and academically-struggling were sampled to make comparisons across the spectrum on factors that are contributing and hindering student persistence. Attention was paid to sampling across ethnic and racial sub-groups and to interviewing male and female students to uncover gender differences related to retention. See Table 6 for definitions of sub-groups.

Fourteen individual student interviews were conducted. Interviewees included 11 women (1 Native American, 2 Hispanic, and 7 white females), and four men (3 Native American, and 1 Hispanic males).

Faculty and Staff Interviews

Engineering faculty members from across the engineering disciplines were interviewed to explore their perceptions of factors that influence underrepresented women and minority student persistence in engineering and engineering-related degree programs. Faculty interviews also served to provide faculty perceptions as to the functioning and effectiveness of the MEP in helping to retain minority students. Faculty

were selected for interviews based on the criteria of teaching or having taught the engineering core courses required of all students, and/or sponsoring clubs or research projects with minority and women students. Eight faculty members (5 males and 3 females) across four of the engineering departments were interviewed.

MEP Staff Interviews

MEP staff members including the director, a graduate assistant, and a student worker were interviewed to gain an understanding of program functions, services, and effectiveness. MEP staff members were also questioned regarding their perceptions of factors contributing to persistence of women and minorities in engineering degrees offering a view from a perspective that differs from the ways in which faculty members are involved with students.

Document Analysis

A final source of data for the study was analysis of documents related to the MEP. These included historical documents describing the inception and original program goals for the MEP as well as yearly reports and grant applications related to expansion of MEP efforts. In addition, in-house evaluations of services conducted by the MEP staff were examined for further insight into program effectiveness. Documents were examined for illumination of the original rationale for developing the MEP including assumptions and theoretical underpinnings for program design. Documents were also examined to bring to light decisions regarding program services and staffing, and to look for interactions between programmatic decisions and student impact.

Data Analysis

Qualitative Data Analysis

The nature of emergent design in qualitative inquiry allows the researcher flexibility in developing the study as it progresses to allow for fruitful data collection and analysis (Patton, 2002). Interview questions for this study (Appendices D - G) were intended to be generative in nature allowing for interviewees to respond based on their own perceptions of what hinders and supports women and minorities while pursuing engineering degrees. Where themes of interest emerged, the researcher probed for depth and understanding.

Content analysis is a process by which qualitative data are reduced for the purpose of "sense-making and the identification of core consistencies and meanings" (Patton, 2002, p. 453). Focus group, and interview transcripts, as well as program documents were examined for recurrent themes, relationships, patterns, and anomalies. Data from digitally recorded interviews and the single focus group was transcribed to text files which were then imported into qualitative analysis software (N6 or Atlas). Data analysis began with the process of open coding of the data. Open coding of qualitative data involves a generative process of identifying concepts contained in the data. To "uncover, name and develop concepts", the researcher must "open up the text and expose the thoughts, ideas, and meanings contained therein" (Strauss & Corbin, 1998, p. 102). During the process of open coding, the researcher began to see how categories (phenomena) relate to one another and connections began to emerge.

Once categories were identified through the process of open coding, axial coding of the data followed. Axial coding is the process whereby categories are related to subcategories, and categories are collapsed into other categories along the lines of their properties and dimensions (Strauss & Corbin, 1998). Axial coding of the interview and document data in this study allowed for connections to be made and theories to emerge from the data set regarding influences on persistence of minority and women students in the study.

Quantitative Data Analysis

Grade Point Average Comparisons

Analysis of Variance. Using the Peoplesoft database, a single-factor, independent-measures Analysis of Variance (ANOVA) was employed to examine whether differences exist in student GPA by ethnic/racial categories. The database contained five racial/ethnic categories: Native American (N = 93), African American (N = 7), Hispanic (N = 44), Asian American (N = 13), and White (N = 587). African American students and Asian Americans were not included in the analysis due to inadequate sample size. To ensure equal sample sizes for the ANOVA, Native American and White student groups were randomly sub-sampled to include 44 students from each group in the analysis, thereby equaling the number of Hispanic students in the database. Missing data were excluded from analysis. Data were screened for normality and

homogeneity of variance and both assumptions were met allowing for the ANOVA to be conducted and ensuring validity of results.

The null hypothesis tested in this analysis was that there were no differences in mean GPA between ethnic groups: i.e. H_0 : $u_1 = u_2 = u_3$. Post-hoc Tukey HSD tests were performed to determine where differences existed between racial/ethnic group GPAs.

T-Tests. A t-test was used to test for differences in overall mean GPA between males and females. For this test the null hypothesis was that there is no difference between men and women in overall mean GPA, i.e. H_0 : u_1 = u_2 . A t-test was also employed to test for differences in overall mean GPA between minority MEP and non-MEP minority students. For this test the null hypothesis was that there is no difference in GPA based on participation in MEP STAR-PALS programs: H_0 : u_1 = u_2 .

Academic Status Comparisons

Definition. To define students' academic status, SPU uses a combination of credit hours earned and cumulative GPA. To be considered in Good standing a student with 0-14 total credits earned must have a GPA of 1.8 or higher, students with 15-29 earned credit hours must have a GPA of 1.9 or higher, and students with more than 30 credit hours must have a GPA of 2.0 or higher. Students who fall below the criteria will have an academic standing of Probation at the end of the semester. In the following semester, if the student maintains a 2.0 GPA but does not raise their overall GPA to 2.0 or higher, they will be on Continued Probation. If the probationary student does not achieve a 2.0 or higher GPA in the following semester, they will be academically suspended.

Two-way contingency table analysis. A two-way contingency table analysis was conducted to evaluate whether there were differences in academic standing based on ethnicity. For the purpose of analysis, the categories of probation, continuing probation and suspended were collapsed into a single category of "other than good standing." Therefore the two variables in the two-way contingency table analysis were ethnicity with five levels (Native American, African American, Asian, Hispanic, and White) and academic status with two levels (good, and other than good). Significant findings led to further pairwise comparisons between all ethnic groups (ten comparisons in all). The Holm's sequential Bonferroni method (Holm, 1979) was used to control for Type I error at the .05 level across all ten comparisons.

Chi Square Test for Independence. A Chi Square Test for Independence was utilized to determine whether there is a relationship between group membership (MEP and non-MEP minorities) and academic standing. In this case, the null hypothesis tested was that there is no relationship between group membership and academic standing (good vs. not good).

Support Ratings from On-line Survey data

Mann-Whitney U tests. In an on-line survey of engineering students, respondents were asked to rate the importance of thirteen factors as sources of support while working toward degree completion in engineering and engineering-related programs (Appendix C). The scale for response was a 1 to 5 Likert scale with 1 being "unimportant" and 5 being "extremely important." Survey ratings were examined for gender and racial/ethnic differences in what students identified as important sources of support in helping them to persist. For each of the thirteen items, the original scores were rank ordered and a Mann-Whitney U-test was used to compare the ranks for differences by gender. A Mann-Whitney U-test was also used to compare ranks for differences based on ethnicity. In each case, significance was compared against a conservative alpha of .01 to minimize Type I error across the thirteen items.

Validity/Credibility

Overview

Validity has been traditionally associated with the positivist paradigm of research where the term refers to accuracy in measuring what one purports to measure. In addressing the concept of validity in evaluation, Scriven (1991) stated: "Valid evaluations are ones that take into account all relevant factors, given the whole context of the evaluation (particularly including the client's needs) and weight them appropriately in the synthesis process" (p. 372). House (1980) discussed validity in evaluation from the perspective of the type of situation involved. In the case of the interpersonal situation where an external evaluator conducts the evaluation in service to the stakeholders, House stated that the evaluation not only must be true, but that it also must be "credible to the audience" (p. 249). The key to credibility in this view is that the audience finds the

evaluation to be trustworthy. Here the evaluator must go beyond the discovery of facts to acknowledgement of the experiences of those involved in the evaluation.

Guba and Lincoln (2000) used the term credibility to address the question of establishing confidence in the truth of evaluation findings. Guba and Lincoln proposed several means of ensuring credibility, two of which will be employed in this study: triangulation and member checking.

Triangulation

Triangulation serves to increase the validity of evaluation findings by utilizing multiple lines of evidence and/or multiple methods to test for consistencies in conclusions (Patton, 2002). Two types of triangulation were employed in this study. Data triangulation (use of a variety of data sources) was accomplished through the use of individual student interviews, student focus group interviews, faculty and staff interviews, document analysis, and an on-line student survey. Methodological triangulation (use of multiple methods to study a single problem) was achieved through the mixed-method design of this evaluation to employ both quantitative and qualitative research methods to examine the effectiveness of the MEP and the factors influencing underrepresented student persistence.

Member Checking

Obtaining feedback from informants concerning interpretation of the findings of the study is one method of ensuring the confirmability of study results (Guba, 1981). Frierson et al. (2002) asserted that the use of review panels of stakeholder groups to examine evaluative findings is one way of ensuring cultural responsiveness in evaluations of programs serving minorities. This is especially necessary when the evaluator is not a member of the cultural or ethnic group of program participants.

One approach to member checking is to present a summary of findings to case informants and to ask them to comment and evaluate the accuracy of inferences and conclusions (Miles & Huberman, 1994). In this study, results were presented to the director of the Multicultural Engineering Program as a means of member checking. This individual is appropriate on many levels: as a female, a Native American, and as an individual who works with engineering students on a level that is more personal than that of most engineering professors. She confirmed the findings of the study and gave

additional insights into issues involving females and women of color as well as issues related to the Multicultural Engineering Program.

Researcher Bias

Bias is a problem in evaluations studies if the findings are shaped by the evaluator's predispositions and beliefs about the evaluand, thus rendering findings that are not credible (Patton, 2002). Scriven (1991) saw the control of bias as a key part of evaluation design. In his view, bias should not be seen "as an attempt to exclude influence of definite views, but to limit the influence of unjustified views, e.g., premature or irrelevant views" (p. 69). In Scriven's view, use of an external evaluator can aid in bias control by eliminating the possibility that the evaluator will favor a program because of "ego involvement or income preservation." And yet, external evaluators are not necessarily immune to the possibility of bias in their studies. The evaluator often comes into the study with preconceived ideas about the stakeholders and program activities. One way to deal with predispositions is to make them overt, and then to engage in a systematic search for alternative possibilities for explaining the phenomena under study (Patton, 2002; Strauss & Corbin, 1998). A technique for examining bias and making researcher assumptions and beliefs overt is the use of a bracketing interview prior to the start of the study (deMarrais, 2004). The bracketing interview process involves the researcher being interviewed by a peer (or self) using some of the same questions she will be using in her study. The bracketing interview is transcribed and coded and later used as the researcher works through the data collection and analysis of participant interviews and observations. A bracketed interview of the evaluator in this study was conducted prior to beginning the study. A graduate of the C&I doctoral program acted as the interviewer. The findings of the bracketed interview will make overt the biases of the researcher so that she may purposefully look beyond any preconceptions to search for possible alternative explanations within the participant data.

Worthen, Sanders, and Fitzpatrick (1997) identified two additional sources of researcher bias that should be monitored during the course of this study: interpersonal relationships and financial relationships. The evaluator in this study has had a high degree of interaction with many of the stakeholders in the evaluation through work on the

Engineering Talent Pipeline project over the past two years. In the process, she has developed a positive working relationship with those directly involved in the grant. Such relationships are essential to the work of evaluation, but can make an honest and open sharing of evaluation results (especially negative results) difficult. Being a paid evaluator for grant activities poses the potential problem of "producing" results to make the grantee look good to the funding agency. The evaluator in this study has adopted an additional strategy suggested by Worthen et al., (p.316) for the purpose of controlling potential bias. This included the keeping of reflexive logs of the evaluator's perceptions, procedures, and insights during the entire course of the study. These reflections were consistently reviewed by the researcher during the course of data analysis to allow for examination of potential bias in the analysis and reporting of research findings.

Summary

The preceding chapter outlined the methodological approach to the evaluation of the MEP and support for underrepresented students in engineering degrees. The evaluation approaches emphasized in the study were explained and a mixed-methods approach to data collection and analysis was presented. Issues of validity and researcher bias were discussed as well as methods used to ensure the credibility of the evaluation findings. The following chapter, Chapter 5, will present the findings of the study.

CHAPTER 5

RESULTS OF THE STUDY

Overview

This study addresses issues of retention and persistence in underrepresented students in engineering, and examines the effectiveness of the Multicultural Engineering Program (MEP) in supporting women, minorities and first generation students in engineering degree programs. The research questions guiding this study are as follows:

- 1. What factors influence retention and graduation of underrepresented women and minority students in engineering and engineering-related degree programs?
 - a. What social integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: peer interactions, faculty interactions, clubs, and competitions.
 - b. What academic integration issues within the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: quality of instruction, difficulty of courses, and pre-college academic preparation.
 - c. What factors external to the university influence underrepresented students in being successfully retained in engineering programs at SPU? Examples may include: cultural, community, and family influences.
 - 2. How do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
 - a. How do minority students who utilize MEP components compare academically to minority students who do not utilize MEP components?
 - b. How do students who utilize MEP components compare to minority students who do not utilize MEP components in terms of satisfaction with their degree programs?
 - 3. Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?

4. Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

This chapter begins by addressing academic achievement and status of underrepresented students from different ethnic and gender groups. Next, findings related to persistence of women and minorities in engineering degrees will be presented. Finally, the findings of the evaluation of the MEP will be presented.

Recruiting women and minority students and faculty/staff members for participation in the study was undertaken through several venues. Resulting participants provided the researcher with the greatest amount of data to answer the research question concerning factors that influence retention of underrepresented students. While there is a significant amount of data related to the Multicultural Engineering Program, recruitment of MEP participants for interviews was not as successful and therefore, findings are more tentative and based on fewer interviews. These issues will be discussed where appropriate in the following results chapter.

Underrepresented Student Persistence

The following section of the results will address the first research question in the study: What are the factors that influence graduation and retention of women and minorities in engineering and engineering-related degree programs? Data collected to address this question included the university's student database, an on-line student survey and interviews of students, faculty and staff in engineering and engineering-related degree programs.

Identifying the Issue: Differences in Academic Achievement

Before addressing the research questions in the study, exploratory analyses were done to determine if there are differences in academic achievement and academic status for underrepresented students in the study. These analyses were done to illuminate any differences between groups and while not the focus of the research, helped in adding to the context of the study.

Grade Point Average Comparisons

Comparisons by ethnicity. A one-way ANOVA was conducted to test the null hypothesis that there is no difference in mean student GPA based on ethnicity for Native American, Hispanic, and White students (H_0 : $u_1 = u_2 = u_3$). Results of the ANOVA showed that the effect of ethnicity on GPA was significant, F(2, 129) = 7.46, p = .001 and therefore the null hypothesis was rejected. Post-Hoc analyses using the Tukey HSD post hoc criterion for significance indicated that the mean student GPA for Native American students (M = 2.49, SD = 0.57) was significantly lower than that of Hispanic students (M = 2.84, SD = 0.53) and White students (M = 2.96, SD = 0.65).

Comparisons by gender. A t-test was conducted to test the null hypothesis that there is no difference in mean student GPA based on gender (H_0 : $u_1 = u_2$). T-test results revealed no significant difference in GPA based on gender t(706) = 1.57, p = 0.115. Mean female student GPA was 2.86, (SD = 0.75) and mean male student GPA was 2.75 (SD = 0.75). Due to low numbers of minority females, there was not enough data to compare minority and non-minority women for differences in GPA.

Academic Status

A two-way contingency table analysis was conducted to evaluate whether academic status differed among racial/ethnic categories of students. The two variables were ethnicity with five levels (Native American, Asian, African American, Hispanic, and White) and academic status with two levels (good, not good).

Table 7 shows academic standing for students in engineering degree programs separated by ethnic/racial categories. Rates of suspension are highest among Native American and African American students. Hispanic students have the highest proportion of students in good standing within the sub-groups.

Ethnicity and academic status were found to be significantly related, Pearson $\chi^2(4, N=750)=14.89$, p = .005. Further pairwise comparisons of academic standing and ethnicity resulted in only one comparison that was significant, between Native American and White students $\chi^2(1, N=680)$, p =.001. A two-way contingency table analysis revealed no significant differences in academic standing based on gender. Table 7. Academic status of students in engineering and related degree programs by racial/ethnic categories.

		Academic Status			Total	
Ethnicity		Good	Probation	Continuing Probation	Suspended	
Native American	Count	71	7	2	13	93
	%	76.3%	7.5%	2.2%	14.0%	100.0%
Asian	Count	11	1	0	1	13
	% within Ethnicity	84.6%	7.7%	.0%	7.7%	100.0%
African American	Count	7	0	0	3	10
	% within Ethnicity	70.0%	.0%	.0%	30.0%	100.0%
Hispanic	Count	43	1	0	3	47
	% within Ethnicity	91.5%	2.1%	.0%	6.4%	100.0%
White	Count	526	27	12	22	587
	% within Ethnicity	89.6%	4.6%	2.0%	3.7%	100.0%
Total	Count % within Ethnicity	658 87.7%	36 4.8%	14 1.9%	42 5.6%	750 100.0%

From the preceding analyses, it is obvious that differences in academic achievement exist between racial/ethnic groups. Where academic achievement is low, rates of dropout or suspensions are high. Native American and African American students have lower grade point averages and higher rates of suspension than do other ethnic and racial groups. Academic achievement is a significant contributing factor in persistence in degree programs, although not the only issue. In many cases, students may be achieving at an institutionally acceptable level academically, but still choose to switch or dropout. Female students achieve at a level equal to that of their male peers and yet females are still underrepresented in engineering and engineering-related degrees. Factors other than academic achievement in underrepresented student persistence will be explored in more depth in the following sections of the results chapter.

Sources of Support

On-Line Survey Results

Support ratings. On-line survey data provided one source of data for identifying sources of support and barriers to persistence for underrepresented students as well as those of the dominant culture. One hundred-thirty students responded to the on-line

survey. Survey respondents include students from across all five engineering majors and all academic levels. Racial/ethnic make-up of respondents closely paralleled that of the engineering student body. Respondent ethnicities included African Americans (2), Asian American (1), Hispanic (8), Native American (17), White (93), International (5), mixed-race (2) and two students of unreported ethnicity. The survey contained a variety of fixed-response and open-ended questions related to sources of support, and questions related to the MEP (See Appendix C)

For all students including white males, factors related to finances were rated highest in importance followed closely by faculty member support. Also rated highly were family emotional support and peer social support. Table 8 contains the mean importance ratings for each item for all students.

Table 8. Mean importance ratings for students responding to the on-line survey (n=130).

Factor	Mean rating (N=130)	SD
Internships	4.09	1.16
Scholarships	3.98	1.36
Faculty Members	3.92	.961
Family emotional support	3.85	1.18
Peer social support	3.60	1.14
Family financial support	3.53	1.41
Peer study groups	3.43	1.21
Career counseling	3.26	1.30
Learning Assistance Center	3.15	1.40
Loans	3.09	1.60
Clubs	3.02	1.20
MEP tutoring	2.20	1.21
MEP staff	2.19	1.14

Survey ratings were examined for gender differences in what students identified as important sources of support in helping them to persist. Women ranked five factors significantly higher than male students: family emotional support (z = -2.756, p< .01), peer study groups (z = -2.672, p<.01), scholarships (z = -3.073, p< .01), MEP tutoring (z = -2.742, p = .006), and MEP staff support (z = -2.919, p = .004).

A few differences also emerged when minority and non-minority student ratings were compared. Non-white students rated three factors significantly higher (p< .01) than did white students: scholarships (z = -4.450, p = .000), MEP tutoring (z = -3.984, p = .000), and MEP staff support (z = -3.984, p = .000).

Open-ended survey responses. Thirty-four students responded to the open-ended question "Are there any other sources of support that are or have been important to you in helping you to complete your engineering, computer science, or construction management degree?" Nine students elaborated on the importance of faculty members in helping them progress in their programs. Comments were related to the accessibility of engineering faculty, the "open-door" policy that is perceived by students, and to the "close student-professor interactions" they are able to experience within the programs. Five students reiterated the importance of peer relationships as a source of support. One student expressed that "the peer pressure to do well" was a source of support in helping him achieve. Another student relied on peers who were ahead of him in the program to mentor him through his classes. Other sources of support mentioned by students were grants, jobs, supplemental instruction sessions offered through the South Learning Assistance Center and a single response that church groups were an important source of support.

When asked if there are sources or types of support that would be helpful to students that are not currently offered, the most common responses concerned facilities. Comments related to facilities included wanting improved computer labs with 24 hour access, and a single comment requesting an "engineering library." Other sources of support that students felt they would like to have but did not were more scholarship opportunities. There was a single comment asking for "more grade-based scholarships; not just scholarships that are based on ethnic/racial background" and two responses citing negative faculty relationships. One female, minority student commented that she would like more information on the MEP support program.

Use of Campus Services by Non-white Students

Students were asked if they used campus-based support services. Of the twenty-eight non-white students responding to the survey, 60% utilized Learning Assistance Center tutoring, 36% used the Multicultural Student Center, 29% used Native American Student Services, and 21% used the Gateway Center. Least used were Student Support Services (14%), Career Services (11%), and the Counseling and Testing Center (3% student).

Interview Data

The on-line survey of students in engineering and engineering-related degree programs offered valuable insight into how minority and female students compared to white, male students who were not interviewed for the purposes of the study. The survey provided a point of triangulation of issues raised in student, faculty, and staff interviews. Results of interviews of students, faculty, and staff will next be examined to identify issues related to persistence of women and minorities in engineering degree programs. Due to the small number of female faculty in engineering programs and concerns of confidentiality, gender is often not identified in quotes attributed to engineering faculty members. Interview questions for faculty, students, and MEP staff can be found as Appendices D –G.

Social Integration Factors Related to Persistence

Peers as a Source of Support

"The support from my peers is most important because it really does suck most of the time and we don't have much of a life, but everyone is going through the same thing." (Female 1st generation, Hispanic)

"Oh, the students who do well in those sophomore classes are the students who have figured it out, they have found each other." (Engineering faculty member)

Peers emerged as a significant source of support for the women and minority students in the study. Engineering faculty also recognize the importance of supportive peer interactions in helping students to succeed in their degree programs. Nearly all of the students and five of the eight faculty members interviewed mentioned peer interactions when asked what types of support are most important in persistence. Peer support can take the forms of organized study groups, emotional support, and mentoring.

Female students and faculty specifically mentioned the importance of study groups which can serve both as an academic support and an emotional support. This finding was supported in the survey where women rated the importance of study groups higher than did men. A single male student mentioned studying with a friend as important stating: "it is good to have a friend who has been through what you are going through." Successful students find the advantages of study groups early in their careers and often stay with the same groups of students for studying throughout their years as a student:

If you have problems with homework, other students will walk you through it if they understand it. When we study for tests we get together in groups and meet to study. We always are working together. In your freshmen and sophomore years the LAC gives you study groups and there is a tutor up there that will run over all of the homework for you. Once you get to your junior and senior level classes you don't have that anymore so you rely on each other more. We've been in the same classes for so many years that we all know each other. (Female, White, senior)

One faculty member who felt strongly about the importance of study groups facilitates the process of getting students together in his class by "mixing them up and getting them to know each other in class and getting them to meet with each other to study." He sees the bonds formed in his freshmen and sophomore level classes continuing as he watches students progress through their academic careers.

For the female students in the study, study groups are equally important in fulfilling the needs for social interaction as for helping to work through course assignments and test preparation. Being involved in a rigorous and intensive degree program allows most students little time for socializing. Peer study groups become a social outlet as well as an academic necessity. Several students commented that because of the socializing that goes on while studying, study groups may take more time, but the trade-off is in the emotional support they provide. A typical comment was expressed by a female interviewee: "we study but we have fun too, we're pretty laid back. It takes more time because we slack off; but really study groups (make things more comfortable)."

Faculty members have identified peer study groups as facilitating the problemsolving process for many students. As expressed by one faculty member:

If they're studying alone then whatever they think of they try. But if you have four or five other people saying 'let's try this or what if you do this,' then it usually gives them other ways to work problems. And they can discuss concepts and hopefully work through some misconceptions.

Study groups can serve another purpose as well. Students and faculty spoke of the tendency of study groups to foster a collaborative body that seeks to make sure all of its members succeed academically. A faculty member stated: "The students who perform best in class tend to have peer study groups that are very active and very supportive. And they take it very personally to carry everybody, to float everybody to a higher level of performance."

The idea that peer support needs to come from students within the same academic programs was a common thread in talking with both faculty and students. There were multiple references by faculty and students concerning the importance of having someone to lean on "who knows what you're going through." Mentoring relationships often formed as a result of these interactions. Several students mentioned the importance of having someone ahead of them in the program that could help them to navigate through courses and interactions with faculty.

While peer support in the form of study groups, emotional support, and mentoring were common instances of peers as a positive influence on persistence, negative aspects of peer interactions also emerged in the course of this study. These will be explored in the following sections.

Negative Peer Interactions: Competition, Gender Ratios, and Peer Sexism

When asked to comment on anything that made them uncomfortable in the engineering environment, two of the men, both computer science students, commented on the competitive nature of the classes. One of these (a Hispanic, senior) talked about how competition was fostered by the professors in his classes:

It is a very competitive environment. One of the things I don't like about it is that the sheer competitiveness between students sometimes lends itself to professors, not necessarily having favorites, but they know who the kids that are really bright are and they tend to ignore the rest of us. They don't do it on purpose and they don't necessarily pick someone, but we all are in awe of the ones who are very smart and usually they are pretty nice kids and they will help you out. But, it does create a certain atmosphere like you don't want to look like the

one who is not as smart. It is not negative, but it does create an environment where it does not foster openness or collaboration.

This same student went on to talk about how in his internship work, he found the opposite to be true; in a real-world work environment there was a great deal of collaboration and teamwork to solve problems collectively. He had a difficult time resolving that with the environment he faced in the classroom. The other male student, a Native American, also felt intimidated by other students who could work at a faster pace than he could: "there is competition with other people, so it can be intimidating ...people who know more than you do and they can get the program done faster than you can. There's just that type of intimidation." Comments concerning competition in a negative light were isolated to the two computer science students. Students from other engineering majors spoke more of the collaboration and teamwork they experienced in classes, especially in the design courses required of mechanical, electrical, civil, and environmental engineering students. In those classes, team approaches to problem solving were built into the curriculum and students were rewarded for being a successful member of a team.

Female students faced competition in a different form, i.e. being female in a maledominated environment, and feeling that they need to "prove themselves" in ways that male students do not. This sometimes led to uncomfortable interactions with male peers. Issues related to gender will be explored in the following sections.

Gender Imbalance

"In one class for the first few weeks I was the only female in the class, now there is one other, but I look around and see 19 and 20 year old guys and it is almost a culture shock" (Female, White, freshman)

Women make up 15% of the engineering student body at SPU. In certain majors, such as computer sciences, they make up as little as 9% of the student population. No one is more aware of the lack of females in engineering than female engineering students themselves. The topic of the gender ratio in engineering programs was raised in every interview conducted with female students. The topic of gender imbalance was sometimes raised in response to questions about challenges students had to overcome while pursuing degrees, sometimes in response to questions concerning things that had made them

uncomfortable, and sometimes in response to questions about what they found surprising along the way. A sophomore student expressed it this way:

I guess it was uncomfortable when I walked into my first class, first semester and I was the only girl. I was trying to figure out, "where are all the girls?" (Laughs) But I got used to that because everyone was all right with it.

Another student found the ratio uncomfortable initially but found a positive way to view the situation:

One of the first things that I noticed when I started was that there were definitely fewer women in the engineering program and at first I was intimidated by that, not because of the way I was treated but because there were only two of us in the class. I learned that it is almost an advantage sometimes because professors recognize you more easily. When there are only two girls you stand out more and they know your name and your face so that's nice when you go to talk to them.

Later in the interview the same student responded to a question about whether she knew any women who had left engineering and why they may have left:

I don't know why but I remember in my 180 electrical engineering class there were four girls to begin with and at the end I was the only one. They just sort of disappeared through the semester and I hadn't had a chance to get to know them so I don't actually know why they left.

Although two of the women interviewed were underclassmen, the rest were far along in their degree programs and barring something highly unexpected, would graduate with an engineering degree. These women were goal-oriented, academically successful, and saw the male environment as something they would also face in the work world so they knew they had to "deal with it." The women had experiences that made it easier for them to function in a male-dominated environment. One student grew up with five older brothers which made her comfortable interacting with men. Several women expressed that they had been tomboys as children and had always found it easier to be friends with males. Two of the women talked about not wanting to be part of female cliques in high-

school because they didn't like the "drama" (both used this word) that girls tend to become involved in. Most of the women in engineering talked about already having encountered the gender imbalance in advanced math and science classes in high school so it was not entirely new to them.

The gender imbalance of the classroom is also evident in the engineering faculty male to female ratio, where there are approximately nine male faculty members to every one female. Two of the engineering or related degree programs have no female professors on the faculty. The women that are faculty members are valued by the female students interviewed in this study. A freshman female student talked of having her first engineering class with a female faculty member: "The teacher of that class is a woman so I get to see a nice role model. She is teaching engineering to all the guys and it's nice to see. She is the only female engineering teacher that I have seen."

A graduating female computer science student spoke about how it would have been a motivating force to her to have had a female professor (there are none in computer sciences). When asked what types of support would have been helpful to her that she did not get while pursuing her degree she responded that there needed to female faculty in her major: "...because I'm not sure how you would get the female perspective into this engineering world without actually having a girl there. I mean an actual female professor."

While the women interviewed in this study have successfully dealt with the gender imbalance in the engineering classroom, it is entirely possible that many qualified young women find the "culture shock" too strong to overcome and leave for other majors. One woman spoke of her roommate and her difficulties assimilating into the male environment: "for my roommate, it was an uncomfortable situation because she is very shy and not as comfortable with guys like I am. I'd definitely say that the ratio is uncomfortable for a lot of girls." Another student said "if I was a typical girl that hung out with girls in high school I could see how it would be a major shock like 'who do I hang out with?' They have to learn to get along with guys." "Getting along with guys" may mean having to learn to cope with the sexism inherent in a male environment. Peer sexism was a commonly related issue for many of the women in the study and will be examined in the following section.

Peer Sexism

"There are some gender difficulties; some of the women students have no problem at all, they seem to navigate it quite well. And then there are other students, other women students who have a lot of trouble with that male environment. Sometimes they get through, but other times they have difficulties with their peers and the types of slurs that they perceive, that they feel from their male colleagues." (Engineering faculty member)

"We always get comments about how 'we're women and we're minorities so we get all the scholarships and that's not fair.' "There's nothing for white males." But you have to defend yourself because we get it because we're qualified." (Female, Hispanic, senior)

A thread woven through interviews with female students was the often tricky, sometimes hostile relationships that they have to navigate with their male peers. Seven of the eight female students related some experience with male peers that was challenging to them. An example of this can be seen in an exchange with a graduating, female mechanical engineering student:

Student: The whole interaction with peers, that's probably one of the hardest

things. But I think that as a female student I probably have a different

perspective than other students.

Interviewer: How do you think your perspective is different?

Student: Well, I feel that other people are trying to compete with me more.

Interviewer: Because you're female?

Student: I think it has a lot to do with my sex for a lot of reasons. One would be

that, I don't know if you're aware of this but in industry, I forget what the

law is but you know it's a law where they try to hire certain persons or

minorities. And we're included in that bracket because engineering

doesn't have many females. And so a lot of the male students will

jokingly but also hurtingly make comments such as "you'll only have job

because you're a girl." Things like that. So, I definitely have to put up

with that kind of stuff

This student related that such exchanges with males happened "all the time." She is a highly achieving student with a high GPA in her major, and was extensively involved in clubs and as a peer mentor and tutor. Even so, she still faced male criticism. Her level of confidence in her abilities got her through such experiences, but she speculated: "I think

if I were a female that wasn't doing that well and didn't have the ambitions and what not, it would probably hurt me. It would probably make me feel a little inadequate. And it's a very harsh thing to say really, I think."

At times, peer sexism is not as overt as in the preceding example. A female student related that when put into groups, her male team members almost always assumed she would be the one to take the notes for the group, taking on a secretarial role. Women spoke of having to assert themselves to be equal participants in team work. When questioning why her instructor had grouped the only females in the class together on a team with male students one student posed this idea:

Student:

Maybe it is because the guys are usually dominant and they might push their ideas and do all of the work themselves. Maybe they (the instructors) are thinking that a team with two guys and one girl will completely ignore the girl.

Interviewer:

Has that been your experience with teams of men; that they tend to dominate?

Student:

Sometimes. You have to be real assertive to make sure you are a part of it and you are learning. Sometimes it's hard. I have to watch and learn because I feel like I have to know it before I will do it and they (males) will just do it and learn as they go. That is part of the problem because they will just do it all then.

Faculty members are aware of male-female tensions in the classroom. A male faculty member related an experience of mediating a conflict between two women and one of the men on their team. The instructor offered advice for the women on how to dialogue with a male student who they felt was not letting them participate in a team activity:

He would make subtle comments that implied that they didn't know how to do this or that ...or he could do it better or faster. It was an ego thing on his part and they wanted to do something. They felt that he was not allowing them to participate fully because they were female.

None of the female students in the study related interactions with faculty that would suggest sexism, and there is no evidence that any such overt behavior occurred in interactions between students and professors. However, male faculty members

consistently referred to their female students as "girls" which can have powerful unspoken connotations.

Women commented that they often feel the need "to prove themselves" in a male environment. According to the women, much of this "proving" takes place in their lower division classes. Several commented that once they were juniors and seniors, they were accepted by their male peers and treated as one of the group. All of the women felt supported by faculty in their programs with the exception of one student who had a negative interaction with a particular faculty member. Two of the women expressed that sometimes being female afforded them extra attention from faculty members who were anxious to see women succeed in the programs and made extra effort to check in with them to see if they needed help and were understanding class material. One of the women expressed concern that her male peers made comments about her work being graded easier because she was female, something for which there was no evidence but was another form of the type of sexist comments female students were exposed to.

Social Issues related to Ethnicity

Diversity

"There's like two or three girls every semester. There is not a great diversity among the ethnic classes. I would like to see a greater diversity like we had in (a previous major). That really gives you a good learning experience. You obtain different insights from them and you need that sometimes to solve a problem, different ways of solving problems. Math is math...it's a universal language. But how you learn math, how you approach things, changes from person to person according to your experience." (Male, Hispanic, senior)

Faculty members in engineering recognize the importance of increasing diversity in the engineering degree programs. Several commented on the global need in engineering for diversity of gender, ethnicity, and ways to approach problem-solving as typified in this comment from a male faculty member:

Engineering today is really seeking diversity because the problems we're being faced with really require thinking outside the box, thinking innovatively, creatively. And people from different cultures, different backgrounds, and different genders, even different parts of

the country think differently and so are very valuable in that whole process because you need people who actually don't think alike.

Both faculty members and students expressed concern over the lack of diversity that is still so prevalent in this university's engineering student body. One of the Hispanic students interviewed spoke of going to a national conference for Hispanic engineers and being energized to be among so many people of color in her field: "For me being a part of SHPE (Society for Hispanic Professional Engineers) and going to a conference with almost all Hispanic engineering students is just amazing; it's an experience you can't get anywhere else." Another student spoke of a similar experience with her internship at a major corporation and then of her return to classes at the university:

It's interesting to see that a lot of companies are trying to diversify and they make a big point of that. I am a little bit disappointed that our college is not as diversified as others. A lot of my perspective comes from this summer in a big company. There were only a few women but a lot of minorities. But here, you still walk in a classroom and see the typical white male dominating the room. (Female, Hispanic, senior)

The issue expressed so well by this student is typical of most engineering degree programs nationwide and certainly not restricted to the university in this study. Lack of faculty role models and a critical mass of peers can lead students to feeling isolated within their majors.

From the perspective of several of the students in this study, white male students seem to lack understanding of the need to support women and ethnic minorities with special programs and scholarship and internship opportunities. One Hispanic student talked about her friend who she described as "the typical oppressed white male" and her attempts to increase his awareness. She related a conversation with him where he professed not understanding why there needed to be special professional societies for ethnic minorities. He sarcastically asked her: "Why can't I have the Society of Caucasian Male Engineers," to which she responded: "Because you can't, that's ASME (American Society for Mechanical Engineers); go to ASME and look who's there." She went on to say:

I always get crap for getting scholarships that are directed at minorities and being in clubs that are aimed at helping me even though I convinced him (the same friend) to join the club. Other students make me feel more Hispanic than I actually am sometimes.

Other than references such as the preceding one concerning special opportunities for minority students, there was a consensus among the minority students in the study that they did not feel uncomfortable with faculty or peers as a result of their race or ethnicity. In interviews with faculty members many expressed being "color-blind" with respect to their students. By this, they meant that they made an effort to treat all students equally. It was evident that this attitude sometimes leads to not recognizing differences that might be essential in addressing issues of retention or just with connecting with students on a deeper level. A male student of color expressed it eloquently:

I can't say that I have been treated differently or special at all. I have to say that this group of professors and students are so involved in their academics, that they don't really care what ethnicity you are as long as you get your work done! (Laughs) It's a good thing that there is no time for prejudice but a bad thing that they don't really get to know you as well.

Other ways in which the idea of "treating students equally" might prevent an understanding of essential differences came up in discussions with Native American students concerning learning style differences. This issue will be addressed in a later section of the results concerning academic integration issues and their affect on persistence.

Lack of Peers

"I think, and this may be my perception, I think that anybody who is a minority comes with more disadvantages because there are fewer of them in the classroom so there are fewer people that they automatically gravitate towards and are befriended by." (Engineering faculty member)

While representation of minorities in the engineering programs is quite low compared to white students, only one Hispanic student mentioned a lack of diversity as something he found disturbing: "My major is still one of those areas that is white-male dominated; it is changing but it is a slow change. There is probably less than there should

be in terms of representation of minorities...there are a lot of Mexicans; I wish there were more women and more blacks."

Engineering faculty members and Multicultural Engineering Program (MEP) staff did bring up the issue of the lack of peers and role models for minority students when speculating about the barriers faced by minority students. A white, male professor talked about the issue of underrepresentation and how it may affect students:

If you view yourself as of a cultural type, say African American or Native American, or women, you generally want to study with your type. And given that they are underrepresented in engineering, they have very few people they can study with if they want to study with 'their type'. I don't mean that in a negative sense. But if you're wanting to feel comfortable with your group and the group isn't there, that's a tough thing to do.

An MEP staff member talked about how if students are struggling academically, *and* they feel isolated, the combination may lead to a decision to leave the institution:

And then you're in a place where it is really diverse and I see this with more of our black students. There's not really a black community here and so when you're not seeing that I think it's easier to leave especially when you have academic problems.

It is very possible that other students in the study had similar feelings about the lack of representation of ethnic/racial minorities in their programs but did not feel comfortable discussing the issue with the interviewer who is a white, female. This issue should be further explored beyond the bounds of this study.

Summary of Social Integration Issues

In interviews with faculty members, staff, and students, several issues were raised related to social integration into the university and into engineering degree programs. Peer support in the form of study groups and emotional support was deemed essential to the majority of students in the study, and also recognized by faculty members as a factor in persistence. Negative peer interactions are present in classroom interactions and were overcome by successful students, but may be a cause in attrition in other cases. Lack of

diversity in the student body and among the teaching faculty was recognized by many and may possibly be a factor in student attrition as well. The following section focuses on academic integration factors that affect retention in engineering and engineering-related degree programs including interactions with faculty, teaching, and learning in the classroom and the engineering curriculum.

Academic Integration Factors

Integrating into Campus Life

"Because I think that minorities tend not to go college so they don't come here knowing the academic culture – what a campus is like. And so they may struggle just making that adjustment to understanding what's going on." (Engineering faculty member)

Several faculty members and students discussed issues related to integrating into university life as a possible barrier to persistence, especially for minority students. Integration issues are present on two levels: finding one's way in university/campus life, and at the program level, figuring out the "engineering system." For students who grow up in culturally different environments, such as the Native American students who come from reservations, integration into the university involves change at many levels. A major and obvious change for reservation students is that of going from communities where they are the dominant racial group to coming to a campus where they are part of a much smaller percentage of the population.

For Native American students that were interviewed in this study, having a parent or sibling who had gone to college mitigated some of the stress of the transition to college. A male Native American student working for the MEP stated:

I think for a lot of Navajos, depending on what area you come from they're willing to do it (pursue their degree). If they've seen an older sibling, a family member who has already gone and gotten their education they kind of feel comfortable about leaving (home). And then there's those who if they are the first ones to go it's kind of hard for them, especially for the smaller tribes like the Tohono O'odham.

Coming up to Flagstaff is a big change for them.

But for students who are first generation *and* coming from a different culture the new environment may be overwhelming. As a graduate assistant for the MEP (female, Native American) put it: "It took me a couple of years as an undergraduate and again as a

graduate student to understand the system and I didn't grow up on the reservation. It's not that easy sometimes and for people who have those additional challenges; you might get up and go home."

Faculty and staff expressed that for many students, being able to identify and find the resources that will help them be successful isn't an easy task for students who have no prior university experience. The director of the MEP explained:

Even though (the university) is not that big they just don't know how to navigate and don't have anybody to turn to; and first generation students don't have their parents to turn to. There might be a counselor that they could talk to but they're certainly not going to come here and show someone what an audit class is, what's a Rec fee, what's a meal plan, how to get an ID. Simple things but if you're coming from a first generation family and you've never really stepped foot on a university or maybe you went to a summer program, you still don't know any of that stuff. And so I think that diminishes confidence too.

This idea that confidence may diminish in students who are new to university life and are having difficulties adapting may further add to feelings of isolation in some students and possibly lead them to reconsider an academic career.

Learning the Engineering System

"I don't think anybody expects them to walk in the door understanding the system of engineering, but there is an expectation that they're going to figure it out pretty quickly, although it is a very subtle and unspoken expectation." (Engineering faculty member)

It became very clear in interviews with faculty and students that students in engineering degree programs not only face the transition to university life, but also to becoming part of the sub-culture of engineering education. Successful students come to understand and navigate the "engineering system." Those who do not come to understand the system are quickly weeded out. Several faculty members speculated that the lack of ability to figure out the system was most likely a large factor in losses of engineering students at the end of the freshmen year. One professor spoke of the need for students to learn to organize, plan, and target the work for their classes and that it takes

time and peer mentoring to do so. As he put it: "by the time they hit the junior year the ones who have figured it out are in engineering classes. The ones who haven't are gone." From conversations with this faculty member and the one quoted at the beginning of this section, it was clear that learning how to navigate the engineering system was the responsibility of the students with support from their peers, not something faculty felt obligated to directly address. This may be part of the often cited "weed out" process in the hard sciences. Aside from learning content, learning the process of surviving in the content classes and degree program is an expectation for continuation in the major.

From the perspective of faculty and students, this learning for survival includes generic skills such as how to study effectively, prepare for exams, get projects done in a timely manner, etc. One student described her transition from high school to college: "I still had the mentality that I could do my homework an hour before it was due, and I didn't have to go to class all the time. But college was different." On another level learning the engineering system includes coming to understand the way learning takes place within the academic major. This was especially true for computer science students interviewed for the study. A female, Native American student talked about how she tried to mentor other computer science students through the process of understanding how to learn within the framework of the discipline. She stated:

If you teach them how to do this, then they can do anything. They can learn any (computer) language and how to find references on their own. That's a big thing too- is finding on-line references, finding books that will help you, finding different ways of looking at it that help you rather than just the way the teacher says it or whatever. Honestly, most of my learning doesn't occur when I go to class. I never learned anything in class. I've always learned it on my own.

This student and others expressed frustration that there was little help from faculty to teach the types of skills to which she referred. Another Native American (male) student echoed this sentiment: "The only thing I have had to overcome is trying to understand how things work in the computer science courses and how everything is presented. (My friend) said all the courses are going to be like this". This student was extremely frustrated with an introductory course in computer sciences. He was very

successful in his high school on the reservation and was experiencing academic difficulties for the first time at the university in this particular class:

It was like going from a big tank of fishes to a bigger tank of fishes. The only difference was in my high school I was ranked 6th in my class. I had straight A's in high school and I took Physics and Chemistry and Biology with all A's. When I came here I think it is a little different.

As a result of what he is experiencing in the course, he is reconsidering his major in computer sciences.

One faculty member felt that she and other faculty members were probably outof-touch with how stressed students are with making the integration into the major and coming to understand how to work within the discipline. This faculty member said, in speaking of her own career as a student: "I probably pick up things a lot faster than the students we have here at SPU. And I think that's typical for all the professors and I don't think we really appreciate how hard the students are struggling and just not getting it."

Part of what many students are struggling with is the expectation that much of what they learn will be undertaken outside of the classroom. This was a common theme in interviews with students. Sometimes this expectation was directly addressed by professors as one student explained: "The first day of class they tell you this degree takes a lot of self-learning and a lot of self-motivation. Maybe even above and beyond what many other degree programs have." For most students, though, the expectation that they will have to learn many things on their own comes as a surprise. Faculty acknowledge that for some students the expectation of self-directed learning is too much. When speaking of why one student had switched from mechanical engineering to construction management a faculty member said:

... especially in that sophomore design course where we really just kind of throw students in and don't give them a lot of tutoring, and a lot of expectations that you just have to start figuring this out on your own, I think was very frustrating for him. He didn't appreciate that at all.

The expectation of self-directed learning is one that was voiced by most of the faculty in this study. Successful students are the ones, who according to one professor "understand what their role is in all of this; it doesn't fall in their lap. They have to teach themselves essentially how to learn on their own." Interviews with successful engineering students give evidence they that have mastered an understanding of learning within the structure of the engineering disciplines and an ability to learn independently from what is presented in class by their professors. It is likely that many students who have the talents to be successful engineers are lost because they receive little help in "learning the system" and would likely benefit from some sort of overt method of addressing this expectation.

The Engineering Curriculum

Difficulty Level and Workload

"Being a student of engineering, I can say right away that you can always tell just by walking around campus who is a student of engineering and who is not. You will never find an engineering student out there playing Frisbee or getting a suntan; it is rigorous and definitely involves some dedication to keep on pursuing it." (Male, Native American, junior)

When students were asked in interviews, what has been challenging to them while pursuing their engineering or engineering-related degrees, almost unanimously they answered that it was the level of difficulty of the curriculum and the workload in their classes. Several said that when they knew of other underrepresented students who had left the programs it was not due to any racial/gender discrimination; it was due to the academic demands placed upon them. Faculty members shared this view of why students leave. One stated: "I think the sophomore retention is very much related to the fact that these are very hard courses. This is where they have to get a clue."

For students who have been successful and reached the threshold of completing their sophomore year, there is a strong sense of pride that they were doing something challenging and difficult. As expressed by one female student: "It is very challenging and I like it. Once you say you are in engineering, people say 'oh, that's hard', but I love it. It is nice being challenged and knowing that not everyone does it." For the most part students said that they "knew what they were getting into" when they chose to major in engineering so it was not a complete surprise for them, although for several there was an

adjustment from their level of achievement in high school to what they were experiencing in college courses. This discrepancy could lead to issues of self-doubt and lack of self-confidence. An engineering staff member spoke of it this way: "There are students that have come in that have been A students and start seeing themselves as B/C students and lose that confidence and go elsewhere. I think that's true for minorities and women. It's a confidence issue."

Students and faculty members alike talked about where the interplay of academic challenges and self-doubts may interact to lead to decisions to leave the major. This was especially apparent in discussions with and about female students. A female engineering professor made the following hypothesis:

I think that the women who go into engineering or many women in general...women are more perfectionists and they accept less faults in themselves than men do, I think. And I think- I've seen enough girls to say this- that a girl who's getting a C in an engineering class will switch her major so that she can get A's in another major rather than stick it out like a boy will. And I don't know if that's sexually specific; because I've seen lots of guys who are perfectly happy with Cs and Ds. They're just going to be an engineer. And the sad thing is, is that they work out to be fine engineers eventually, usually. So I think that's why we lose (female) engineering students is because women are taught... they're raised in such a way that they're always trying to play catch-up.

Several female students related similar ideas concerning the interplay of confidence and academic performance. One student said "I think women do drop out because they think they're not as good as the guys, but you can't look at it that way." Another said that the only thing she has found uncomfortable about pursuing her degree is "not being able to do as well as I would like to do because of struggling with material; and I don't like that." A third female student talked about how, unlike herself, her male peers always seemed so sure of themselves:

There might be a difference between the self-confidence of the male students versus that of the female students, but I am not sure. I have tried to observe and see; it might be but I really don't know. I have talked to them about the fact that they are so sure and they say that even when they aren't they will argue their point anyway, where I will not unless I'm sure of it. I need to be sure of what I'm arguing before I step into the debate.

Connections to the Greater Good

"A lot of the women in the college, for instance, I think have been civil or environmental, especially minority women which kind of makes sense because I think they want to go back and help their nation." (Engineering faculty member)

Two of the Native American students and several faculty members talked about the need for social relevance in the engineering curriculum as a factor related to persistence for women and minorities. As one of the students put it:

There is no conflict between my culture and what I am learning. In my culture it is good to learn and adapt and bring home the shared knowledge. It would be great if I had all of this knowledge without actual grades because the grades kind of puts you where you are as a person and I have that sense that I don't want to have to prove anything; I just want the information to give it to my people.

Speaking of a female student who was considering switching from the major, one professor said: "The few experiences I've had with women thinking about leaving engineering, I think it's very much framed in that idea of needing a more human social perspective of their careers than what they're seeing with engineering." Connections to the "real-world" and to relevance to society may be factors to consider in helping to retain women and students of color in engineering programs.

Engineering Faculty

"My professor has kind of taken me in (he is my advisor) and helped me to figure out where I am going and how to finish. It has been pretty valuable having the one-on-one interaction with the faculty because before I declared my major, they did not really help at all with my schedule. Once I got in the program I became part of the community." (Female, White, sophomore)

As discussed earlier, on-line survey results indicated that engineering students placed a high degree of importance on faculty member support in helping them to persist

in their degree programs. This finding was strongly corroborated in interviews with engineering students regardless of gender or ethnicity. When asked what sources of support had been most important to them while working on their degrees, thirteen of the seventeen students interviewed talked about faculty members in the engineering and engineering-related degree programs. For many students in the study, smaller class sizes and the fact that professors and not graduate assistants taught introductory classes was one of the reasons they chose to attend this institution. One student stated: "the interaction with the faculty is good. I love how small (the university) is because by the time you get to your second or third year all of the teachers know you so it is real easy to approach any of them." Faculty approachability was mentioned by many of the students as a positive aspect of faculty interactions that contributed to persistence. One student expressed a commonly held view that "the professors are always there to talk to whenever you want." Another felt that new students coming into the degree programs should be mentored in learning to build faculty relationships because they are so valuable:

I have always been intimidated the first time I go to see a professor but they have always been very welcoming, helpful and supportive. The professors have helped me to feel comfortable in class and to understand the material. It would be good to help new students with respect to speaking with professors, knowing how accessible they really are. They always say they have office hours but when you are a freshman you don't really understand the value of that – that you can go and talk to them if you have any questions.

An engineering professor echoed the idea that building relationships with faculty members was something that distinguished successful students from those who were less successful:

(What makes them successful is) the degree to which they work collaboratively and consort with their peer students and take advantage of the relationships they can build with faculty. Those that tend to try to go it alone – that's a real trial for them. So, the degree to which they integrate with their peer students and take advantage of building

faculty relationships outside of the structured lecture environment is a factor (in persistence).

Students felt supported by faculty members to seek help when they needed it. They talked about professors giving home phone numbers so that students could contact them with questions concerning homework and also that they responded promptly to emails concerning assignments. Aside from help with coursework, faculty members have aided students in finding scholarships, internships, and job opportunities. Several students expressed a sense that their professors care about their progress. This was especially important to female students. One stated: "I have had teachers who really want you to know the material when you leave and if you don't know the material then they feel as if they have failed. It comes across; you can totally tell which teachers are like that." A female, Native American transfer student compared her experience at this institution to that of her previous (very large) university:

What I find comforting is that open door policy where the professors are willing to be there and sit down with you. It is not so formal and I have the feeling that they understand what I am going through, that I'm a student and I want to succeed. I find it very comforting that they want to help you.

This sense that someone is monitoring their progress and cares about them is a strong motivational factor for the students in the study. A male, Native American computer science student related an uncomfortable experience with a faculty member who confronted the student while he was working (at a student worker job):

There was one time, it wasn't in the classroom. After awhile when I think about it, it was really nice of the professor. It was a computer science professor, and I was working. He actually came to me at work with my boss behind the desk and started yelling at me about how I'm not putting out my workload. I was all like, 'okay that's meant for another time, another place not my work, not in front of my boss.' But when I think about it he actually did care and he wanted me to succeed.

So while he felt the faculty member's methods may have been questionable, in the end the student saw this as a constructive interaction. He saw it as the professor caring enough to want him to do the level of work that he was capable of doing.

Although the majority of the students felt faculty were an asset to their persistence, there were two students who had had negative experiences with faculty members that were enough to make them reconsider their career paths. Both were Native American computer science students, one male and one female. The male student was mentioned earlier as the student who was having a particularly negative experience with his first introductory computer science course: "I have been thinking about changing my major because I have the feeling that the instructors want me to fail the course so they can get on with their lives." The female student, who was graduating with a dual major, found her interactions with faculty to be impersonal. She felt more at ease with her second major and would continue on in graduate work in that field. In addition to these students, a third female student had had a negative interaction with a faculty member in a lower level course, but felt that as she progressed through the program and "proved herself", he became more approachable and more willing to assist her in her studies.

Female and minority students alike felt that faculty did not discriminate against them due to their gender and/or ethnicity. For the most part, faculty voiced a commitment to diversity in their fields. Three of the eight faculty members interviewed had been involved as faculty sponsors for clubs targeting women or minorities in engineering, and two of the faculty members were involved in the Multicultural Engineering Program's summer bridge program for minority and first generations students. An area where faculty members' tendency to "not notice differences in gender and ethnicity" may hamper beneficial interactions with students is in the lack of recognition of learning style differences in the classroom. This will be examined in the following section.

Pedagogy

"In engineering, it's word for word, note for note on the board and you've got to write it all down because it could possibly be on the test. And you, a lot of times, just didn't worry about understanding it at that moment in time because you didn't have enough time or you would miss the next thing they wrote on the board." (Female, white, senior)

Interviews with students revealed that most of their experiences in engineering classrooms consisted of direct instruction and note-taking with little give and take between students and professors. The exception to this is the core Design for Practice (D4P) curriculum consisting of four engineering design courses taken by all majors (except computer science and construction management) from freshman through senior years. The Design for Practice curriculum was awarded Boeing's Outstanding Educator Award and features classes that are team-oriented and student-centered in nature, taking students through the engineering design-build-test sequence. Most students mentioned the D4P classes as those that allowed for collaborative learning and a way of practicing team skills that will be essential to them in their careers. Their other courses, for the most part, were taught in a very traditional direct instruction format. Lecture and note-taking were the norm for most classes and for the most part students saw that as a function of the type of material they were learning:

In engineering it is more fact-based; the teacher gives us facts and we kind of give them back a couple of weeks later. I think I might have a problem with that because I like learning with a discussion- based sort of thing. It's hard to do that in engineering. There's not a whole lot of objectivity. In my English class we do a lot of discussion and bantering and I like that. It might just be a function of the type of class, I mean, the teacher gives the facts and it really doesn't need discussion. There is just one way to do things and one way that things are compared to discussing literature. (Female, White, freshman)

Two students said that direct instruction was the way they learned best and therefore, they liked the way courses were taught. Four of the eight faculty members talked about how they themselves had learned engineering in very traditional lecture-driven classrooms. They had experienced success in traditionally taught classes yet were mixed in how they valued alternative methods of instruction. One professor talked about how she learned best from direct instruction but knew that for many students, there was a need for more experiential learning even though it was uncomfortable for her: "Because I'm very theoretical and I've come to understand that most students, and it doesn't matter what kind of student they are, they all respond to a little project 'hands-on-y' thing."

Students most appreciated classes where "real-world" connections were made. One of the professors interviewed in the study talked about being very explicit in making those connections. This professor taught in a traditional manner, but was cited by students as a good instructor because of his deliberate attempts to connect the learning within the course to other classes they were taking. Students also benefited from the team-orientation to the D4P and other classes where peer collaboration was emphasized.

Much of what was discussed by students as the ways they learned best are methods that prove effective for all students regardless of cultural background or gender. Two Native American students (both male) and two faculty members discussed the need for more visual presentation of material as a pedagogical technique benefiting native students. As one of the students explained:

A lot of Native American students do learn through visual and tactile learning which I find is true for me as well. I have to visually see it in order to understand it so if it's like theory or anything like that I do kind of bad in it, because I can't visually see it. I have to kind of draw it as best as I can or put it in some format where I can see it. That's the major problem that most minorities have or at least within the Native American group is that they have to visually see it.

This student went on to suggest that it would be beneficial for professors to have a better understanding of learning styles of native students: "if teachers were to understand that Native American students do have a hard time learning through words alone that would help out a lot." The need for visual ways of presenting material was echoed by the other student who said: "I am a visual person so I have to see it; I get lost if someone is just speaking it to me." When prompted for what they meant about "visually" seeing the material, they referred to having more ability to manipulate things, or to draw and diagram what they are learning. Two of the faculty members expressed awareness of the need for instruction that incorporated multiple modes of learning. One faculty member talked about how many of the techniques that benefited native learners were also beneficial to other student groups:

I think traditionally the way different social groups may have grown up, they are either more verbal or more visual or depend more on the written information. The lineage of how that may have come up with the different groups is I think what we're associating with 'That's just how they are'. When in fact I think everyone would like and deserve a little bit of everything and we shouldn't sort of tag the White Anglos 'well they're okay because they can just read something out of a book and they'll get it'. I think a mixture of everything is what's beneficial.

The second faculty member talked about the need for faculty development to increase understanding of learning styles: "I feel that it's really imperative that faculty get a lot of faculty development and training so that they can understand that there are people with different learning styles, with different ways of looking at things that aren't wrong, they're just different." This was the only instance where a faculty member in the study suggested the need to further understand these types of cultural and pedagogical issues.

Summary of Academic Integration Issues

To integrate into the academic life of engineering degree programs, several factors were important to the students in this study. The ability to understand the often unspoken expectations for learning the "engineering system" was a factor that separates successful and non-successful engineering students. Building relationships with faculty members both in and out of the classroom is essential for students to persist. Being comfortable and adept at learning within a highly traditional teaching and learning format was also a characteristic of students who were successful in persisting in engineering programs. While some faculty expressed an understanding of the need for variations in teaching methods as beneficial to most students, most admitted that they were uncomfortable with going beyond a traditional lecture-driven format for classroom instruction. The following section addresses factors external to the university that affect student retention in engineering degree programs.

External Factors Affecting Retention

Family Relationships

"My wife has obtained her degree and is now supporting me in the background while I go get mine. I would say that as far as the emotional part, I have a large upper hand than for a student all by themselves. And that I do not take for granted!" (Male, Native American, junior)

The emotional support of family was rated high in importance by all students on the on-line survey with a mean importance rating of 3.85 (N=130, SD=1.18). For minority students the mean rating was 3.92 (N=25, SD=1.35), and for women 4.35 (N=31, SD=0.88). During interviews, discussion of family influences emerged in many of the exchanges with students, faculty and staff as a factor affecting persistence in college and in engineering degree programs. Eight students, five of whom were minority, mentioned family as a source of support in helping them to persist. For the students in the study, family included grandparents, parents, siblings, uncles, and spouses. A first generation Hispanic student relates how powerful the support of parents can be:

My parents, brothers and sisters have been extremely supportive. I come from a very successful family, academically speaking. Although, my mother barely finished high school and my father barely finished junior-high school in Mexico, I have three sisters who all have degrees – one's a programmer, one's a doctor, one's a hotel manager. My older brother has a degree from here in HRM and my younger brother is graduating this semester and another one on the way. Education has always been supported in my family.

For some students, family support came in the form of following siblings or other family members into engineering programs, or into college. A senior female student talked of how seeing her older brother's senior design project inspired her to choose engineering as a major. A Native American student spoke of an uncle who had graduated with a degree in Biology and how he is a source of support in terms of understanding the workings of campus and college life. A Hispanic female student talked of her father who is a mechanic and how she grew up with her head inside car hoods watching and helping him work and how it inspired her to go into mechanical engineering. She also spoke of her mother who has been, in her words, "reaming self-confidence into her head" for years and has made her feel she can accomplish anything she chooses. This student along with her sister is the first on either side of the family to go to college. As she puts it: "My parents don't really care what we do, they are just happy we are in college."

A faculty member sees family as a source of support when students are struggling with self-confidence: "You don't do well in the class, you don't do well on the exam and you need someone who loves you to say 'it's okay, you're going to be successful.' Just sort of that unconditional support rather than a professor who's sitting here going 'well you should have done this and this'." In this respect, a married Native American student talked about how he feels he has an advantage over other students in having the emotional support of a spouse to help him through a challenging period in his life.

For traditional Navajo students, part of the decision of coming to SPU was made due to the fact that it is geographically close to the Navajo reservation where they grew up and their families still reside. Being close to family is important for native students from a cultural perspective:

My mom really wanted me to stay close by for several reasons. And a lot of them are very cultural reasons because, you know, (this town) is located at the base of one of the four sacred mountains and it's still located within Navajo territory. And so there's traditional beliefs that if you stay within your traditional homelands that you're much more protected. And plus, if I ever got sick I thought I could always go to a medicine man and be close by. (Female, Native American, senior)

Another Navajo student talked of a similar need for family and related spiritual support to help him persevere: "My family is supportive. Last Friday I had a Blessing Way ceremony to strengthen my spirit and give me a positive outlook on life."

While for minority students, family and cultural support are significant factors in persistence, families can sometimes be a source of interference with academic pursuits. Native American students may be called home for ceremonies or to help with family issues. This was also mentioned by engineering staff as being true for some of the Hispanic students in the program:

I think culturally, I've seen this in Hispanic and Native American families that the family is so close knit that there are certain responsibilities you have. If there is a ceremony going on then you're more than likely expected to be there to help. In a Hispanic family there are sixteen-year birthday parties and things like that going on and

you are expected to be there. In a close-knit family, you should be coming home every weekend or the majority of the weekends.

Family responsibilities may also include living at home while attending college and being expected to care for younger siblings or grandparents and tend to household chores while trying to keep up with the work of a demanding academic program. Other issues related to family responsibilities that were raised by students, faculty, and staff included the need for better child care options for women with young children trying to pursue a degree. Overall, students felt that family were there to support them and were proud of their academic pursuits, a fact that students find helped to motivate them when they were struggling.

Cultural Influences

"You know probably it's a more competitive environment here at the university than what they have at home, especially with Native American students and with women it would be a lot more of a male environment so they're adjusting to that." (Engineering faculty member)

Closely tied to family influences are the influences of culture on the persistence of minority students. As previously discussed, the white, male world of engineering can present problems to female students who find it difficult to adapt to the "mainstream" culture within the major. This can also be true for Native American students for some of the same reasons and for others that are uniquely related to the culture in which they were raised. Two of the native students that were interviewed talked about how they found it very uncomfortable to be judged with grades and scores on exams when what they really wanted to do is learn what they need to learn to become competent engineers and to use the knowledge to better their communities. The emphasis placed on grades and scores by their classmates and professors can be antithetical to the things that were motivating them to pursue their degrees in the first place.

For native students, cultural norms within the predominately white university can be quite different from what they have known all of their lives. Most of the faculty members interviewed in the study talked about the "quietness" of native students and related it to the students feeling uncomfortable in "asserting themselves or their ideas," which is often contrary to the expectations placed on them in the degree. An engineering staff member, herself a Native American, described it very well:

Native Americans... you're told from kindergarten to be quiet in the classroom, be quiet in the hallways; don't be loud. But you get here to college and you're expected to speak up and you haven't been taught that, or it's not in your culture to do that, or it's disrespectful. You don't want to boast about yourself or highlight yourself or anything; then that's difficult too because then you're in a setting where you are expected to do that. Or you're expected to be able to express yourself in an interview well and you're not used to doing that. And you're certainly not used to telling someone how wonderful you are and why they should hire you.

Faculty and staff talked about one issue raised by the preceding quote, that of questioning those in positions of authority. The idea of faculty as "elders" came up in several interviews. It may be viewed by some native students that to raise a question in class or challenge a grade is disrespectful of the "elder" in the community whose experience and wisdom is beyond what they possess. One faculty member said:

I know that that's very much a cultural thing but in the engineering programs there does seem to be a relationship between having the ability to sort of assert yourself because sometimes you are wronged. And... sometimes to be able to assert that, to make those statements... I've noticed that some of our native students are reluctant or uncomfortable speaking out.

When asked to talk about a minority student who they remember as being outstanding and to describe their characteristics, faculty members often described students that had obviously assimilated into (or were possibly raised in) the mainstream white culture. One faculty member recalled an impressive native student as "very outspoken, very articulate student, a very dynamic speaker. He'd do well in any Caucasian male setting... very smart guy. And he was outspoken." For this faculty member, what made this particular student stand-out were characteristics that paralleled those of the successful white male student.

Related to the "quietness" of native students is a tendency described by several faculty members for these students to want to hang back and have a firm understanding

of something before they begin to put forth ideas or designs. This was mentioned earlier as a similar characteristic of female students when interacting with their male peers. One faculty member hypothesized that native students may be uncomfortable with showing an elder the mistakes that occur in the trial-and-error design process. His thought is that native students want to show the professor something that is more complete and less flawed rather than the earlier stages of the design. He related, "I think it's a cultural bias toward demonstrating your capacity to fail to an elder and moreover to an Anglo elder, somebody outside of their immediate culture." He went on to say that he did not see the same reticence in Anglo students: "They're very willing to come up and say 'well I tried this and it didn't work, and I tried this and it didn't work'. They actually take some pride in demonstrating all the things they tried and failed at." He felt that to be more effective with native students, professors needed to find a way to make the trial-and-error process more comfortable for them.

One faculty member did not agree that quietness was necessarily a challenge to persistence. This professor made the distinction that although native students tended to be less outspoken in class, they were obviously engaged during collaborative efforts with their peers. They may not be the ones who speak for the group but they are nonetheless involved and active in the learning process.

The teamwork aspect of the engineering curriculum appeared to benefit minority students. The students and their professors noted that collaborative learning activities allowed for community-building among team members as they worked together to solve a problem. An interesting perspective on this came from a Hispanic student whose family came from Mexico. In his words:

Coming from a culture that is poorer than that of the United States, forces you to collaborate. So that makes you seek out collaboration and teamwork; you have no choice because of the resources. There is a scarcity of resources so you have to work as a team in order to maximize the benefit of the resources.

The relationship between collaborative problem solving and community betterment seems to be a motivating factor for minority students. This can be a stark contrast to the

white, male engineering student who is "out to prove himself" and is often rewarded for working in isolation to solve a problem as proof of his intelligence and ability.

A final way in which culture has influences on persistence comes from interviews with several Native American students and Native American staff members. Three of the Navajo students talked about their spiritual beliefs and how those beliefs and practices support them in their academic lives. These students talked about having ceremonies performed for them by medicine men to strengthen and protect them and to help them in their educational pursuits. This added support in terms of spiritual and religious beliefs was mentioned only by native students in the study and seems an important source of support for them while attaining their degrees.

Finances

"I actually wasn't considering college until I found out I had a full tuition waiver to a university. And then, I sat down with my grandparents and we discussed it and they said there's no reason why you shouldn't if it's already going to be mostly paid for." (Senior, White, female, first generation student)

The preceding quote demonstrates how much of an impact financial issues can have on bringing students to the university and in retaining them. The student quoted here graduated recently with a 3.85 GPA (outstanding for her field), was highly engaged, motivated, and involved, and did well in her internships experiences. She will undoubtedly make a good engineer who might not have been, had financial aid not been available to her. As noted earlier, on-line survey results showed that for all students, financial aid especially in the form of scholarships is highly rated in importance by all students with a mean rating of 3.95 (N = 130, SD = 1.36). Financial assistance is even more important to underrepresented students in the study. For first generation students, the mean importance rating for scholarships is 4.29 (N = 38, SD = 1.18), for minority students 4.52 (N = 25, SD = 1.05), and for women it is 4.61 (N = 31, SD = 1.42).

Student interviews confirmed the importance of scholarships as a source of support for the students in this study. This makes sense especially when the majority of students do not complete an engineering degree in four years. Five years is the accepted norm for degree completion in most engineering programs and in computer sciences. Therefore, the cost of obtaining a baccalaureate degree is often higher for students in engineering degrees that for students in other majors. The financial payoff for successful

completion of an engineering baccalaureate degree is high. According to the College Journal, an on-line publication of the Wall Street Journal

(http://www.collegejournal.com/salarydata/engineering/engineering.html) students who successfully complete an engineering or engineering-related degree can expect a starting salary of roughly \$50,000 - \$55,000, much higher than that of most fields for applicants holding a baccalaureate level degree. Students and professors spoke of salaries for certain engineering professions as even higher, closer to \$70,000 starting salary. Therefore, students will be financially rewarded for the extra time it takes to complete their degrees, but they often need financial aid to make it possible.

The engineering and related departments have a full-time staff person who acts as a scholarship coordinator as well as providing information and aid on student internships and career placement. Ten of the students interviewed in this study found the scholarship coordinator to be an invaluable source of support for them in completing their degrees. Recently, the scholarship/internship coordinator took another position within the College and a replacement has not yet been selected. What students found helpful was the level of involvement the past coordinator had in connecting them with scholarship opportunities. This individual kept a database of students, and when a particular scholarship came available, went through the database and contacted by email all students who met the minimum criteria for the scholarship. She often followed this up with personal phone calls to students who had not applied, but she felt were qualified:

I have received a National Science Foundation scholarship through their office and, as I understand, it was a pretty prestigious scholarship to receive and I was very happy to get that! I never heard about it until she called me up and that is how I learned that they actively look for stuff (for students). And her services not only go within the semester; she has contacted me throughout the summer, as well, about internships to apply for. (Male, Native American, junior)

Students greatly appreciated the individualized efforts made by the engineering scholarship/internship office to help them through their programs. This office often works in tandem with the Multicultural Engineering Program staff to provide information to students on scholarships and internships for minority and women students. Several

minority and women students in individual and focus group interviews mentioned that the partnership between the MEP office and the engineering scholarship office had been a strong source of support for them. Students were referred back and forth between both offices for information on particular scholarship opportunities.

A second issue related to finances arose in student, faculty, and staff interviews: that of students working while attending college. For many students, working an outside job is a necessity to meet living expenses while they are in school. Engineering and engineering-related degrees are highly demanding in terms of student workload for individual courses and many students find juggling employment and homework to be daunting to say the least:

One semester I was working two jobs, 40 hours a week and I was having some family problems and was I was taking four classes. And I ended up getting D's in Calc III and Statics, a basic engineering course. I was like 'I don't know if I can handle this anymore.' (Female, Hispanic, senior)

One faculty member estimated that over 50% of students have performance issues because they are working in addition to taking classes:

Maybe they feel a little stressed out because they're working a parttime job and some of them a full-time job and aren't able to get classes when they want to get them so that delays when they can actually graduate. I think all of that builds gradually into a sort of a stress that impacts what they're doing in class and how they're doing in class.

The demanding curriculum and drop off in performance due to work commitments can cause students to suffer the potential loss of scholarships that require them to maintain a specific grade point average. This becomes an added source of stress for some and faculty and staff conjecture that this can lead to students switching to less academically demanding majors to make the work/school balance achievable.

Other Findings Related to Persistence

"That is what keeps me going: the intellectual challenge, the respect of my peers and the self-motivation of just wanting to finish." (Male, Hispanic, senior)

"There's going to be times in engineering when they're not going to be so successful. And they're going to have some bumps and they have to be willing to persist through that. And perhaps it's that overarching goal of really wanting to be an engineer that perhaps gets them through." (Engineering faculty member)

Many of the students interviewed in this study are in their junior and senior years of their degree programs. They have crossed the threshold where they were at risk of switching majors or dropping out, and have gone on to be successful in their academic careers. Aside from the findings already cited, there are certain more intangible characteristics of these students that are instrumental in keeping them on their academic paths. These characteristics are of a more intrinsic nature yet seem to be held by the majority of successful students in the study.

First among these is a very strong desire to persevere. Goal commitment is high for the students in the study and they are willing to put up with a number of adverse conditions to finish their degrees. The internal motivation for these students was often the intellectual challenge and the pride they take in being a part of an academically rigorous program. Female students are willing to put up with uncomfortable relationships with male peers. Native students are willing to persevere through teaching that doesn't meet their needs. All students are willing to make the sacrifice of "having no life" because of the time demands of their courses. They understand that they will likely need five years to finish their degree. Several students talked about repeating courses until they got the grade they wanted and needed to continue. A particularly interesting exchange occurred when a Native American student related his "plan of action" for getting through his computer science degree:

Student: Well it's just so much information that you have to pass down with each

class. They have to go through so much stuff in a single semester that it's not possible. They teach it too fast. You can't get the concepts; you can't

all the stuff you need.

Interviewer: So what have you done to try to overcome that?

Student: So far, my whole plan of action has been I take it, probably don't pass it

and retake it again to replace the grade.

Interviewer: And you usually do okay that second time around?

Student: Yeah the second time I usually do. After that you understand what you're doing. After that even if the teacher is going as fast as he can you understand what they're doing.

Examining this student's academic transcripts revealed at least three different instances where he has taken a course, received a D or F and then repeated the course for a better grade (twice for an A, and once for a B). He credits his "will to succeed" with keeping him in his program. Although employing a unique strategy, this student's will to persevere was common to most students in the study.

Along with a high level of goal commitment and intrinsic motivation to complete their degrees, many of the students interviewed in the study are highly involved in academic life. Engineering clubs and competitions figure prominently. For many students, taking on leadership roles in organizations, mentoring younger students and working closely with their professors factor into their immersion into the culture of engineering education. A strong desire to be proactive in all aspects of their education is apparent.

Summary of External Factors

Factors external to the institution exert influence over students and their decisions to persist in engineering degree programs. External factors identified in this study include the emotional support of family and the responsibilities associated with family members. Cultural influences such as the desire to share learning among one's community members are a motivating factor for Native American and Hispanic students in the study. Cultural norms that are different from those of the dominant white, male culture of engineering may pose assimilation issues for native and Hispanic issues to persist in engineering and engineering-related degrees. Financial issues are particularly relevant to engineering students who often take five years to complete a baccalaureate degree. Help in finding scholarships through the engineering scholarship office and the MEP is greatly appreciated by students in the study. And finally, a strong will to persevere and a high level of goal commitment and involvement characterize students who are successful in engineering programs. The next section of the results will turn to examining the Multicultural Engineering Program and its effectiveness as a support mechanism for underrepresented students in engineering degree programs.

Evaluating the Multicultural Engineering Program Overview

Research questions two through four involve examining the Multicultural Engineering Program (MEP) and its effects with respect to helping underrepresented students to persist in engineering and engineering-related degrees:

- Do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
- Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?
- Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

Data relevant to these questions includes evidence from program documents, program records, on-line survey results and student, faculty, and staff interviews. Several avenues were used to recruit students for participation in interviews specifically related to the MEP. After repeated attempts, a single focus group consisting of three MEP students was held that offered some insights into program functioning. In addition, several of the underrepresented students interviewed about factors related to persisting in their degree programs specifically mentioned the MEP as a source of support. Where this occurred, the interviewer probed more deeply into students' knowledge and perceptions of MEP activities. All faculty members were asked about their perceptions of the functioning of the MEP and their thoughts on its effectiveness (Appendix D). MEP staff members were interviewed in-depth regarding the program and its many elements (Appendices F-G).

This section of the results will begin with a discussion of the MEP history and related issues of staffing and funding. This will be followed by a look at student retention and academic achievement of MEP students. This section of the results will conclude by examining the strengths of the MEP, and areas of concern.

Program History

Program Inception

Program documents reveal that during the academic year 1992-1993, an individual on loan from IBM was added to the engineering faculty on a faculty loan for

one year. Part of his purpose was to examine issues of Native American student retention in engineering degree programs. During the year, among other things, the individual acted as a counselor and advisor for recipients of a Native American scholarship program, as advisor to the Native American engineering student organization, and conducted visits to reservation high schools and community colleges. The same individual proposed the creation of a Minority Engineering Program (MEP) as a pilot program for the 1994-1995 academic year. The initial program was modeled after successful programs in place in California and other parts of the country. Original program documents state the goals of the MEP are "to increase and enhance the academic performance and graduation rates of minority engineering students." The program began with a five week summer bridge program, Pathways Leading to Success (PALS) in the summer of 1994 enrolling sixteen students of Hispanic, Native American and African American descent. During the summer bridge program, students received university credit for Math, English and engineering preparation courses. Fourteen of the sixteen students enrolled in the fall of 1994. Program elements during the academic year included the following: clustering in key classes, a mandatory freshmen orientation course, mandatory study groups, tutoring, and a studying/gathering area for students to congregate. The current program elements that have been retained from the first year of MEP are the freshmen orientation course, tutoring, and a studying/gathering area. Students are no longer clustered or placed into mandatory study groups.

Staffing

At its inception, the MEP was staffed by a full-time director, a Hispanic coordinator, a Native American coordinator, a counselor and a full-time administrative assistant. Initial funding for the program came from NASA and several industry partners including Honeywell and Ames Research. The university contributed funds toward staff salaries. After 1997, the initial director left, and staffing was reduced. For several years, the program had a quick turnover of directors (in two year intervals) and reduction in staffing continued over time to the point where the current MEP has one funded position, that of a full-time director. Corporate funding has been less over the years as corporate sponsors struggled with their own financial issues. For the last three years, the Hewlett Engineering Talent Pipeline (ETP) project (a five year grant-funded program) has

allowed funding for student workers, and a graduate assistant to assist with advising and to coordinate program activities including tutoring and mentoring. The current director has also taken advantage of Hewlett ETP funds to expand services and programs provided by the MEP. This has included the addition of a student-student mentoring program and a one-week summer engineering camp for high school girls. The Hewlett project funds will end in 2008.

Status of the STAR-PALS Program

As previously mentioned, the STAR-PALS summer bridge program has been the cornerstone of the MEP. Students interested in engineering that are accepted to the university and to the Successful Transition and Academic Readiness (STAR) summer program may also apply to be a part of the PALS program where students attend afternoon sessions focusing on engineering and computer sciences. Students who were interviewed and questioned about their involvement in the STAR-PALS program felt that the program offered them a way to become integrated into university life prior to starting their first semester at the institution. They met professors in the various engineering degree programs and gained a better understanding of the different disciplines within engineering, construction management and computer sciences. A newly matriculated freshmen student said:

It got me familiar with the professors and the atmosphere here. You can't really know what it's like until you are here. With the (STAR-PALS) program, we were all in the same dorm and we got to know a lot of people. It was kind of like getting a head start.

Student evaluations at the end of the PALS summer bridge program cited "covering all forms of engineering" as the most beneficial aspect of the engineering-specific sessions. Students felt they had a better understanding of what each sub-discipline of engineering entailed. Also cited frequently by students was the opportunity to "meet professors and make friends with other engineering students" as program strengths. The majority of negative feedback from students had to do with length of sessions and facilities (students were in swing space).

A faculty member who has been actively involved with the PALS summer program for several years talked about how he has found it to be important in connecting

with underrepresented students. He has followed the progress of many of the students who attended his sessions in the summer bridge program through their years in their degree programs. He said, "They always remember me and I remember them." For some students, having a faculty member who knows them by sight and by name has helped them feel less isolated and more confident as they begin their degree programs as freshmen students.

The STAR-PALS program has involved a significant investment per student each summer. Projected costs for the summer 2006 program are \$2860/student for housing and meals. Additional costs for the program are salary for staff and for faculty who teach afternoon sessions to the students. The university's STAR program pays for room and board for ten STAR-PALS students each summer. The remaining students are paid for from the MEP budget largely funded in the past three years by the ETP project funds. The MEP portion of the five week budget is close to \$40,000. Corporate donations for the program have declined in recent years. Discussions between the dean and the MEP director have led to the speculation that the amount of funds going to serve 20 students (who may or may not be matriculating as engineering students in the fall) may be better spent elsewhere in support and expansion of MEP services that will reach more students. Data collected this summer will aid in the decision-making process concerning the fate of the PALS component of the STAR summer bridge program.

Retention of MEP Students

The tracking of students who have been part of the STAR-PALS summer bridge program since its inception in 1994 has provided the only retention data for students using MEP and services. Within the present academic year, the current director has begun tracking student use of MEP tutoring, mentoring, advising, and social support activities. These services may affect student retention rates, but the tracking is too new at this point to draw any comparisons to students who do not use the services.

Data for STAR-PALS students shows that retention rates have risen and fallen with two other factors: stability of directors and availability of funds. From 1994 to 1997, retention of students who participated in the summer bridge program under the initial director with a full staff averaged 55%. After reductions in staffing and turnover

of directors, retention of 1998-2001 STAR-PALS students dropped to an average of 33%. Under the current director and increased funds and staffing (student worker positions) through the availability of ETP project funds, retention rates have begun to climb. For students participating in the summer bridge program in 2004, retention is at 65%. This figure is more aligned with current retention rates of all students in engineering degree programs which range from 59 - 70%. Retention in the preceding examples is based on retention within the university whether in engineering or other degree programs.

Academic Comparisons

Data for academic comparisons between PALS summer bridge students and those not in the program, is limited. Surviving program documents and records are scarce during the years between the initial MEP director and the current director. The only surviving report is of the first year's activities and outcomes. The report cited higher GPAs for Native American students who had participated in the PALS summer bridge program and the subsequent academic year clustering and academic support programs. The director's report cited an average GPA of 2.30 for PALS Native American engineering students at the end of their first semester at the university, compared to Non-PALS Native American students' average GPA of 1.16. It is not possible to ascertain whether the higher GPAs were dependent on the summer program activities, the clustering and academic support that happened during the first semester, a combination of both, or other factors entirely. It is important to note however, that the initial program had five staff members to serve sixteen students, compared to a single fully-funded staff member in the current program which probably means that resources existed to monitor students very closely as to needed support.

A t-test was conducted to test for differences in GPA between students who had participated in the PALS summer bridge program before entrance to the university (between the years 1999-2004) and those who had not. The null hypothesis for the test was there is no difference in GPA between PALS and non-PALS students: H_0 : $u_1=u_2$. Results of the t-test were not significant t(215)=0.378, p=0.378, and the null hypothesis was retained. No significant difference exists in GPA exists between PALS and Non-PALS Native American and Hispanic students who are currently enrolled in engineering degree programs. Chi-Square tests for independence revealed no significant

differences in Native American and Hispanic PALS and Non-PALS students as to academic status.

Record-keeping under the current director has improved considerably from that of her predecessors. Tracking of academic achievement of PALS students as well as students who are participants in the mentoring, tutoring, and social activities of MEP has begun in this academic year. This will enable more accurate analyses of the influence of MEP on academic achievement in the future.

MEP Strengths

Student Contact

In January of 2006, the engineering and engineering-related degree programs reoccupied a completely renovated building after a year of being housed and conducting classes in temporary "swing space." Faculty and staff were asked for input on the new building's design. The MEP director argued for (and won) space for an MEP lounge for student use. The MEP student lounge is located next to the MEP staff offices and is in addition to another student lounge housed elsewhere in the building. Once in the newly remodeled building, MEP staff began tracking visits with staff and use of facilities. For a one month period from January 30th through February 24th, a total of 53 different individuals used the lounge and/or visited MEP staff for a total of 118 separate visits. Thirty-two (60%) of those individuals were Native American, twelve (23%) were White, three (6%) were African American, one was Asian, one was Hispanic, one International and 3 were of unknown ethnicity. Students visited MEP staff and used the facilities for various reasons (see Table 9).

Table 9. MEP staff visits and use of facilities in a one month period: 1/30/06 - 2/24/06.

Purpose of Student Visit	Number of visits
Studying in the lounge	42
Use of computers and office equipment	15
Academic advising	12
Social use of the lounge and informal visits with MEP staff	16
Meeting with the MEP director	17
Tutoring/Mentoring program information	6
Financial aid/internship information	5
Information on clubs/career fair, other	5

It is clear from the records of contact and from student interviews that students of color (especially Native American students) found the MEP to be a place where they can gather to study, socialize, and seek information in an accepting and welcoming environment. The MEP staff members have become an important source for obtaining information. Meetings with the MEP director dealt with issues as simple as obtaining information on how to get a parking permit, to asking for letters of recommendation for scholarships and internships.

When asked in interviews about what things had been particularly helpful to them while seeking their degrees, six of the fourteen students who were not a part of the MEP focus group discussion mentioned the MEP and MEP staff as sources of support. An exchange with a male, Native American student typifies the type of support staff members provide:

Student: Well, with MEP it's nice to know there's somebody there that's actually

willing to help you, actually there that you can turn to. I know if I didn't

have MEP I'd probably feel a little bit more isolated within the

engineering degree.

Interviewer: In what way would you feel isolated?

Student: In the way that you can't really talk to anybody about anything. When

you're in the engineering building it's like work, work, work. But with

MEP this is like work but you can have fun with it.

A faculty member expressed a similar view of the MEP:

I think it's really good for those students to have a place where they feel like they can walk in and someone's glad to see them. Because I think they feel probably some hostility in other places, whether from other students, whatever. You know if I was one of two or three Native Americans in a class of fifty, that's hard.

Two of the freshmen students in the focus group interview were introduced to MEP staff and services while attending the summer bridge program. These students felt that they had someone to go to if they had issues or concerns, or needed help navigating campus life. One student said: "they're there to help me out providing resources, answering questions about clubs, scholarships, and anything related to engineering."

MEP staff members (particularly the director) knew students on a personal level that may not be achieved by faculty members. The director talked about getting to know students' families, calling students in to meet with her when she hadn't heard from them in awhile, and checking on their progress in classes. In her words, "we just try to keep them on track and help them pick themselves up when they're not doing as well as they want to, and then celebrate their small accomplishments whether it's just a better grade on an exam or graduating." Students feel that they can seek out the director's advice on a wide range of issues from academic advising to helping them to resolve conflicts with professors. For minority students who may be "quieter" in nature and less confident about approaching professors or seeking out campus services on their own, having a source of personal and academic support, and individuals who care about their progress, can mean the difference between staying and leaving.

A female, Native American student found in the MEP director (who is also Native American), someone who understands her from a social and cultural perspective:

I've always had the experience of being a minority person and so I've really never shared that side of myself with anyone at least that didn't already have some interest in it, or was of the same cultural background. But I think seeing (the MEP director) around is really good. Sometimes I go see her. I mean I don't really have much time and I feel bad about that because I never really just visit her. But if I need to go talk to her she's there.

In engineering degree programs that do not have a single Native American faculty member, the director and student workers (three of four are Native American) serve as role models and as highly visible members of a minority group in an environment dominated by white males. A Hispanic male student also spoke of the value of MEP staff as role models. Speaking of women and minority students he said: "MEP really fosters a good network and it is a good role model for freshman who might feel out of place."

Fostering a Sense of Community

As was noted earlier social integration into the institution and into the community of engineering is a strong motivator in student persistence. Interviews with several new and continuing students reveal that MEP played a significant role in fostering a sense of

community, especially among underrepresented women and minority students. The MEP hosts social gatherings each semester which are open to all students. These include a Multicultural Student Reception once a semester that is attended by 20-30 students, mainly minorities. The MEP also hosts an ice cream social at the start of the academic year. Engineering faculty members are encouraged to attend and an opportunity is provided for students to meet professors in an informal setting and to obtain information about programs, services, and student clubs available to them. A female first generation student who became involved in MEP mentoring and tutoring programs stated: "A sense of community, I think, is what helps people stay, feel like a part of it. MEP does a really good job in trying to get people to have that sense of community." Social activities offered by the MEP provide new students with an opportunity to interact with peers as well:

There have been ice cream socials for the engineering department students and those have been real helpful. Because the classes aren't discussion-based you don't get to know the other students at all and it's good to have something outside of class for that. (Female, freshman engineering student)

This sentiment was echoed by another student who said that in classes with group projects he was able to get to know other students, but that MEP social gatherings offered a venue to meet other students with whom he might not otherwise interact.

In recent years, the MEP program has also sponsored a Diversity Reception the night before a career fair sponsored by the engineering departments. Companies such as Boeing, Raytheon, and others send representatives to the career fair to talk with students about job opportunities with their companies. The Diversity Reception takes place the night before the Career Fair and offers an opportunity for women and minority students to meet company representatives in a smaller more informal setting. Two of the female students interviewed in this study found internship opportunities through the Diversity Reception. They were able to spend more time talking with companies eager to increase the numbers of women in their companies. A successful internship experience has led to one of the women being offered a job at Boeing upon graduation.

Tutoring

Program records show that MEP tutoring reached approximately 200 students in the 2004-2005 school year. Tutoring services are open to all students regardless of ethnicity or gender. The intent is to provide a means of connecting students with a tutor for classes not served by the Learning Assistance Center tutoring program and to offer tutoring on a one-on-one or small group basis. The director commented, "We realize that some students really work better on a one-on-one basis and for some students it's better for them rather than being in a group setting or having to make an appointment." The MEP tutoring center is located within the engineering building for easy access by students. Almost all of the faculty members interviewed in this study make students aware of tutoring opportunities available through the MEP program. With increases in funding from the Hewlett ETP grant, more tutors have been hired and tutoring services have expanded. No data have been collected as to the impact of MEP tutoring on student achievement. Interviews with students in engineering and computers sciences programs revealed that most students have utilized tutoring at some point in their academic careers. This was confirmed in the on-line survey where 71% of students responded that they have used Learning Assistance Center tutoring and 59% of students want more information about the tutoring opportunities provided through the MEP program.

Peer Mentoring Program

Through funds available from the Hewlett ETP grant, the current MEP director instituted a peer mentoring program. Freshmen and sophomore students are paired with junior or senior mentors in their degree programs. Past attempts at mentoring programs have included pairing college engineering students with high school students, and pairing working engineers with college students. Neither program seemed to be successful due to difficulties in sustaining the mentor-mentee relationship. Current efforts at peer mentoring, though new, seem to be showing promise in helping to retain underrepresented students. Three junior/senior students acting as mentors and three freshmen students mentioned the mentoring program as a source of support in pursuing their degrees. Upperclassmen acting as mentors saw the experience as benefiting them as much as the underclassmen they are mentoring. A female, Hispanic student who is acting as mentor expressed that she wished she had had someone to mentor her in her first two

years in college. She said, "When I was a freshman and sophomore I didn't really have someone to tell me that I needed to be in study groups, I needed to be in clubs. I hope I can pass that experience along to someone else." When asked what he gets out of the mentoring program by acting as a peer mentor, a male Native American student said:

Out of that relationship I have gotten friendship, for one. I've had the chance to meet new faces and the events they offer through the mentoring program provide a sense of community among all the individuals who are involved. You see them on campus and you feel more comfortable because you don't feel like a stranger out there. It's pretty hard to go through education alone, so it is a very nice program in regards to that.

Mentees see the relationship as offering someone who understands what they will face as engineering students and help them to navigate the system. One student felt that her mentor helps in "getting to know somebody who is in your major and asking questions to see if I really want to do this. Talking about professors-who to take and not to take, getting their help."

MEP staff members have seen positive effects in students who are part of the mentoring program. A doctoral student who is a graduate assistant for the MEP program has been heavily involved in the mentoring program. She feels that the mentoring program is possibly the most effective program offered through MEP in terms of student retention:

We see a difference in the students in terms of their self-confidence. Sometimes their GPAs go up, sometimes they don't. But it really does help the retention I believe. They don't just drop out and go away. It provides for them somebody who is also a student, who understands the challenges - and there's no baggage attached to that. It's somebody they can ask stupid questions of, somebody they can hang out with, somebody they can commiserate with and I think that's important

The peer mentoring program is in its infancy and further data needs to be collected to track the progress of students participating in the program to accurately measure its effectiveness with respect to retention and academic success of those who participate.

Leadership

As previously mentioned, the MEP has undergone several changes of directors since its inception. The current director stepped into a position that was not well defined and was expected to take control of the program with little to no training. She stated:

The directors that were here didn't leave a legacy behind. They didn't leave any historical information behind. Even the person before me didn't leave anything. I had no training up front. I had no information. I was just hired and put in and "oh you can call (the former director) when you need some help" and that was it. I've done that before in probably all the jobs I've ever had; I've had to pick up and kind of do my own thing.

Part of "doing her own thing" has involved implementing several new programs intended to benefit underrepresented students. Availability of funds through the ETP project have allowed MEP to expand its programs to include a summer engineering camp for high school girls (piloted last summer), the peer mentoring program, and the development of pre-engineering math courses for summer bridge students (in cooperation with the director of Upward Bound on campus).

Interviews with the director revealed a highly dedicated individual who was motivated by the students she served. An MEP student worker, who worked for the program under the previous director and the present one, saw the current director as promoting more direct student contact. She confirmed this when asked what she most likes about her job. She responded: "the student contact is great. I mean I'm definitely not one to stay in my office and have the door closed all the time. I really enjoy getting to know them personally." She has a strong vision of where she would like the MEP to be in terms of services it could provide for current students, as well as those in the K-12 system. She discussed at length what she would do if resources were unlimited. Faculty members, students, and staff alike see the current director as an asset to the program. An engineering faculty member noted the change from previous directors to the current one:

You know you need to have a really good person in there that's capable of working alone, working with their own initiative. You

can't have somebody who's not capable of really making decisions and mapping strategies and I think we went through a time when we didn't have that right person and I think (the current director) is a little more motivated and has a better understanding of the broad picture of what is going on.

MEP Areas of Concern

During the course of interviewing students, faculty, and MEP staff, and through data from the on-line student survey, issues were uncovered that, if addressed, could lead to improved functioning of the MEP. These issues will be addressed in the following final section of the results.

Level of Visibility/Awareness of Services

In the on-line engineering student survey, students were asked how familiar they are with the MEP. Of the 130 student surveyed, underrepresented students (n=48) who were targets of MEP activities and services were only marginally aware of MEP. The most common response selected by these students was "I've heard of it, but don't know what they do" (selected by 56% of the students). Ten percent of underrepresented students had never heard of the program, 17 % knew of the program but chose not to participate and 17% participated in MEP activities. First generation students, another target for MEP services, responded in a like manner (57% stated that they had heard of MEP, but didn't know what they do). Students who may benefit from MEP services such as supplemental advising, tutoring, peer mentoring, and facilities for meeting and socializing with other underrepresented students are not aware of what is available to them via the MEP. Currently, STAR-PALS students are actively recruited through outreach efforts. For most of the other MEP programs and services, students are recruited via blanket email, word of mouth and flyers posted on the walls of classrooms and hallways.

During interviews, faculty members expressed similar uncertainty as to what types of services MEP provides and who they are targeting. Faculty that have worked closely with the MEP director on the Hewlett ETP project (she is Co-PI for the grant) have a greater awareness and understanding of the MEP and were its most vocal

advocates. Faculty members seemed to be most aware of supplemental tutoring services provided by the MEP. Most reported that they send students to MEP who need tutoring in classes not serviced by the Learning Assistance Center. Some send only minority students, others send white male and female students. One faculty member expressed frustration at not understanding which students he should be directing to the MEP:

I know several years ago the protocol was if I had a student, any minority including white females, if I felt that they needed some sort of support I could direct them to the MEP program. And I'm not sure that I feel that that has been communicated to me at this point in time. In the past it's what I felt I could do and should do. And now for whatever reason I don't really know whether or not that's still the mode. I don't know what is changed. I feel out of the loop.

Faculty members associated with the ETP grant realize that MEP also offers opportunities for students to meet other students, and is involved with underrepresented student clubs and organizations. All but one faculty member who was interviewed said that they make a point to tell student in their classes about MEP. The remaining faculty member felt that it would be beneficial for an MEP staff member to come into introductory classes to tell students what it offers in the way of student services. Another faculty member also felt that communication with faculty needed to be improved:

The one thing that I think is not as good as it used to be is coordination with faculty in terms of their academic excellence sessions and those kinds of thing. I find out about for my own class by looking around at bulletin boards. They don't try to really communicate as well as they should with the faculty that are teaching classes they are providing sessions for.

The MEP director acknowledges that her efforts have been spent on students and building program and not on faculty awareness. She stated, "A lot of that first year was trying to build those relationships with students and that took a tremendous amount of time and effort. So faculty...I assumed they already knew who we were because it is an established program."

When asked how effective they thought the MEP was in retaining minority students, faculty members that have worked closely with the program gave very positive responses. One stated, "My perception is that they do a darn good job of retaining students." Another said, "My overall impression is that it is a pretty high visibility program and a lot of people use it." Another professor felt that the current director "runs one of the best MEP programs in the country." Faculty who did not work as closely with the program or its director felt they could only speculate as to its effectiveness or did not know. One faculty member stated:

I'm not sure. I mean I don't know. I would think it would be pretty significant because of the connection. They're (minority students) able to connect. They're able to connect with each other; they're able to connect with some of the professors in the program, with (the director) and the people that she works with. So I think that that would make the program pretty effective. They're less likely to be on the fringes; not knowing anybody, not knowing if they belong.

Again, this points to the need for increased communication with faculty members as to not only what the MEP has to offer but what the results are for students who use their services.

Staffing and Funding Issues

Increased awareness of MEP programs and services could lead to a level of student use that is not sustainable under current funding and staffing parameters. As noted, many of the current programs offered by the MEP program are funded by the ETP project. Expansion of "staff" in the form of student workers is largely funded through the same source. Corporate funding in recent years has been concentrated more on student clubs and competitions. According to the MEP director, "Corporate people are not always willing to fund positions. They want things to go more to programs." Several faculty members expressed concern about the future of the MEP program once the ETP funds are gone in 2008. One professor remarked:

As the Co-PI of the Hewlett Engineering Talent Pipeline which supports in large part the MEP, I guess I would express a dire concern about the fact that we're running a major chunk of the MEP right now

on Hewlett soft money. And they will scrape us off the wall here in about three-and-a-half years if we don't figure it out and get on the screen of people who think that's the way it's going to be forever.

Student workers hired from Hewlett ETP funds have allowed the MEP offices to be staffed even when the director is at meetings or on travel. The MEP director sees this as essential since many of the student contact visits that are logged are from students that "drop by" to seek advising or use the student facilities. In her words, with additional office coverage "there is someone there to capture whoever needs help or just someone to talk to." Several faculty members expressed the need for support at the college level for the MEP program. One professor commented:

Well as always the buck stops at the administration who's going to provide funding and support. The motivation and the drive and desire might be there all the time but unless they're adequately funded and supported by the upper administration, they're not going to be as effective as they can be. It's the dean's office that needs to provide the pathway for them to be successful.

The MEP director expressed frustration about the length of time the program has existed without a steady funding stream:

If you look at some MEPs across the country, people who are in my immediate region, I mean they have huge programs. They have their own building and they have their own computer center. I mean, they've got a staff of twenty people and it's frustrating to me that we're not there yet and this program's been in existence for 11 years; and why don't we?

She felt that an established funding stream, allowing for at least one other full-time staff member, would give her the opportunity to refine current programs and establish other programs allowing her to "be more creative and do other things" including outreach to the local high-minority public schools. Availability of funds through the ETP project have allowed for some of the creativity she speaks of. One example is the previously mentioned summer engineering camp for high school girls which was well attended and well received by a group of young women mostly of Native American descent. As one

professor noted, "if you were to ask (the director) to show you the list of things she'd do if resources were nearly unlimited, it would be an extensive list and it would be I suspect, pretty right-on." The doctoral student who was a graduate assistant for the program expressed the issue well:

She (the director) has done an amazing amount with the resources she has. But it is mostly soft-money. She needs more money and space especially if (upper administration) wants her to expand to the college. So if they're really serious about diversifying engineering they need to commit some resources.

Here the graduate assistant is referring to discussions with college administrators who have expressed an interest in expanding the MEP program to serve students from other science majors within the College of Engineering and Natural Sciences. The MEP program has operated for over a decade with little financial commitment from the institution that it serves.

Summary of Results Related to the MEP

The Multicultural Engineering Program at SPU was started more than eleven years ago "to increase and enhance the academic performance and graduation rates of minority engineering students." Reports from the first year of the program show that GPAs of MEP PALS students were higher than those of their non-MEP minority peers. Current comparisons of GPAs show no significant difference between PALS and non-PALS students. The Multicultural Engineering Program at SPU offers support to a population of students, namely underrepresented students, who are at higher risk of dropping out of engineering programs than their white, male peers. Underrepresented students find in the MEP programs and services to support them through their academic careers. An unspecified program outcome, but perhaps the most important one, is the level of personal contact so many students receive by interacting with the MEP director and her student worker staff. Students of color, particularly Native American students, find a place where they can feel less isolated, associate with their peers, and seek help and guidance in a supportive and non-intimidating environment. A newly formed peer mentoring program shows promise in helping students to form peer relationships that are

crucial to persistence. Leadership within the MEP is strong and the current director is constantly seeking to improve and expand upon services intended to improve underrepresented student retention.

The level of awareness of MEP programs and services among students who might benefit from them is an area of concern with respect to program effectiveness. Faculty members in the engineering programs have varying levels of understanding of program services and benefits to students and of which students are being targeted for participation in program activities. Lack of permanent staff and related funding is a major area of concern for the MEP program as is the need for support of the upper administration within the college that it serves.

The preceding results chapter examined the findings of this dissertation study. Results of student surveys, interviews of students, faculty and staff, and examination of program documents and records were discussed in the light of the research questions posed for the study. The following final chapter of the dissertation will address a summary of findings, conclusions related to the study, and offer recommendations for program improvement.

CHAPTER 6

INTERPRETATION OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

In this chapter of the dissertation, the evaluation findings will be summarized in light of the research questions for the study. This will be followed by an examination of how the evaluation findings fit with respect to the current literature in the field. Following that will be conclusions and recommendations for program improvement. And finally, limitations of the study will be addressed, followed by suggestions for further research.

Research Questions and Summary of Findings

Women and minorities are considered underrepresented in engineering because their numbers in the fields of engineering do not reflect their proportions in the general population. For at least three decades, schools of engineering have attempted to address the issues of recruitment and retention of women and minorities through scholarships and support programs. Studies aimed at uncovering underlying issues that affect retention of underrepresented students in the Science, Technology, Engineering, and Mathematics (STEM) have shed light on the problem, but have not led to much progress in changing the demographics of engineering education programs.

This evaluation study examined support for women and minorities in engineering and engineering-related degree programs at a mid-sized southwestern university identified in this study by a pseudonym: Southwestern Public University (SPU). A formative evaluation of the Multicultural Engineering Program was also conducted to examine how well it is meeting its goal of helping to retain underrepresented students in engineering degree programs. The evaluation employed a mixed-methods approach utilizing both quantitative and qualitative data to address the guiding questions in the study. Mixed-methods approaches are based on pragmatic assumptions by the researcher that collecting a variety of data will best illuminate a research problem (Creswell, 2003) and provide multiple data sources for triangulation of research findings. Triangulation of data and methods tests for consistency in research findings (Patton, 2002). Data collected

to inform the study included program documents and records, the university student database, an on-line survey of engineering students, and interviews of students, faculty and staff associated with engineering and engineering-related degree programs.

Persistence of Underrepresented Students in Engineering

The first research question guiding this study was related to uncovering factors that support and challenge women and minority students in engineering and engineering-related degree programs: What factors influence retention and graduation of underrepresented women and minority students in engineering and engineering-related degree programs? The following sections summarize the findings related to this question.

Factors Common to Persistence of Women and Minority Students
Peer Support

For students in engineering degree programs, peer support is essential in helping them to persist. Faculty, staff and students alike all emphasize the need for students to identify other students with whom they can establish productive relationships for studying, mentoring and emotional support. For many students, peer support takes the form of study groups. For women, peer study groups are often an outlet for their need to socialize that fits within a schedule constrained by demanding course work: "we have our little study groups (we do tend to get a lot of homework) so our social life tends to turn to our study groups." Faculty members emphasize the need for engineering students to develop a support network of other students within their own degree programs so that they are associating with others who understand what they face as engineering students. Peer groups can set standards for themselves and take on the responsibility of helping all to achieve those standards. Students remain members of study groups that continue beyond a single class and may last throughout the remaining years of their degree programs. Students and faculty members alike feel strongly that students will have a better chance to be successful if peer study groups are formed early in the students' academic careers. As suggested by one student, "You try to tell the newer students to get in the study groups, get in clubs because it is fun and you get to know people and you get to network." Peer relationships in the form of formalized or informal peer mentoring are

beneficial in helping newer students to learn the ropes and in helping older students to stay connected and motivated while completing their degrees.

Family Support

For minorities and women in engineering degree programs, family is an important source of support. For many students, following a sibling or other relative into the university gives them someone to turn to for help in navigating campus life. For some, an older sibling in an engineering or computer science degree program has offered them a mentor who helped them to integrate into the degree program. Several of the minority and female students in the study are first generation college students who credit their parents with instilling in them the importance of a college education, even though it was not something they themselves had experienced. Being geographically close to family can be a source of comfort for Native students. As one student said, "I figured college was going to be hard enough as it was, so I didn't need to like also freak myself out and not be around my family."

While closeness to family can provide emotional support, it can also place additional demands and responsibilities for some that extend beyond their life as a college student. Attending ceremonies and family celebrations, helping parents raise siblings, and attending to household duties are not uncommon for Native American and Hispanic students. For students with children of their own, balancing their roles as parents with the demands of a rigorous degree program can become a source of stress while attending school. Family demands were cited by several faculty members as reasons why some Native American and Hispanic students have difficulty keeping up with course work: "It seems that the pattern for them if they have to go back home, which we understand if they need to go do something, they should just go do it. But if they haven't communicated that early...I feel like they don't come to class because they're afraid to confront me."

Faculty Support

Students overwhelmingly agree that the support of faculty members is a very important factor in persistence in engineering and engineering-related degree programs. Many students chose SPU over larger state universities because of its student-to-professor ratio and for the "approachability" of its faculty. Transfer students from larger

institutions found the smaller sizes of classes and programs allow them to develop relationships with their professors that would not be possible in a larger school. The fact that professors and not graduate students taught the introductory classes benefited in helping students integrate into their degree programs. The majority of students in the study felt that the faculty members they encountered in their degree programs at SPU were and concerned about their progress and ready to assist them in understanding their course work and finding their way in terms of internships and career opportunities.

Financial Aid

Financial support plays an important role in bringing students to SPU and in retaining them. Most students in engineering will not complete their degree programs in four years. For the typical student, it takes at least five to six years to acquire all of the required courses and electives to graduate. Education costs add up. Students are particularly appreciative of the efforts of the Engineering Scholarship Office and the Multicultural Engineering Program in helping them to find scholarships to offset the costs of their education. The proactive strategies of the former scholarship director were essential in helping students connect with opportunities they might not have found on their own.

Learning the System

Engineering faculty made reference to students needing to "learn the system" with respect to being successful engineering students. Learning the system occurs on several levels. A successful student learns how to navigate university and campus life including locating and utilizing campus support programs. A successful student must learn productive study and work habits. And, a successful student must come to comprehend the way learning takes place within engineering. This includes adapting to or being naturally inclined toward traditional pedagogical methods, and being comfortable with the expectation that a large part of their learning occurs outside of the classroom without the direct assistance of their professors.

Faculty members are clear that students "have to get a clue" on their own.

Faculty members in the study see it as the responsibility of the student to figure things out on their own or with the help of their peers. As one stated, "I don't think anybody expects them to walk in the door understanding the system of engineering, but there is an

expectation that they're going to figure it out pretty quickly, although it is a very subtle and unspoken expectation." The expectation is not as subtle as this faculty member would have it seem. Capable students who do not find the support in their peers for the unspoken expectations could easily be left behind. And yet, faculty members do not see it as their responsibility to make learning the system an overt process. The good students figure it out, the rest change majors or leave the university. In a sense, getting a clue is part of the "weed out" process so common in science degree programs.

Workload

Engineering and computer science students encounter heavy workloads and conceptually difficult classes within their programs. Many students joke of "not having a life" meaning they have little time for social encounters outside of study groups. While students see the difficult workload as a challenge, most have a deep sense of pride in the rigor of their degree programs. If students have figured out the system of engineering, have formed productive peer relationships in the form of study groups and/or mentors, and have strong intrinsic motivation and goal-commitment, the difficulty of the curriculum can be overcome and they are successfully retained.

Perseverance and Goal Commitment

Successful women and minority students in engineering are highly motivated individuals with strong commitment to their goals. Much of the motivation is intrinsic including "seeing themselves as engineers." Experiencing the rigor of their academic programs as a source of pride goes a long way toward keeping these students motivated. A high level of involvement with peers, clubs, and mentoring and tutoring programs is also characteristic of successful engineering students. Underrepresented students persist through academic, personal, and cultural challenges to become successful upperclassmen in their degree programs.

Factors Specific to Persistence of Female Engineering Students

Women make up roughly one-fifth of engineering students at SPU. Analysis of student records indicates that women in SPU engineering and engineering-related degree programs achieve at a level equal to that of their male peers. Issues of retention, therefore, are not related to ability to achieve. Women in the study identified several factors that support them while pursuing their degrees in engineering and identified issues

that have presented challenges to their persistence. As previously noted faculty, peer and family support are all important in female student persistence as are relevance in the curriculum, and successful understanding of the "system of engineering." Interviews with students, faculty and staff uncovered several factors that challenge women while pursuing their engineering degrees and can offer insights into why women leave engineering degree programs.

Gender Imbalance

All of the women interviewed for this study discussed the gender ratios of their classes as something they immediately noticed upon entering their degree programs. It is not uncommon for there to be twenty male students for every female student in engineering classes. For construction management and computer science classes the gender gap can be even larger. For many women, this gender ratio presented an environment that was at least initially uncomfortable, and challenged their confidence in their abilities. Growing up in families with brothers, being "tomboys" in their childhood years, and preferring the friendships of males over females were experiences that tended to define women who had overcome issues related to lack of peers in their programs.

Female professors are few in the engineering programs (less than 10% of the faculty) and they are well assimilated into the male culture. They do not want to be seen as unlike their male peers. As one stated, "I think it probably helps them (female students) to have a female professor in some ways. On the other hand I'm probably not the friendly kind of person they think I should be. I'm the professor, I'm in charge." The gender imbalance is maintained at the faculty level, and successful women tend to do what it takes to fit in with the males around them, i.e. become as much like them as possible. The gender imbalance and all of the nuances that go along with it can very possibly deter highly capable women who do not choose to assimilate into a male environment – those who do not want to become "one of the guys."

Peer Sexism

Women often spoke of the feeling that they had to "prove themselves" in a way that their male peers did not to gain acceptance into the male environment. Proving themselves was most often mentioned in the context of discussing peer relationships, although some women felt that they were also proving themselves to male faculty

members to gain acceptance. Beyond proving themselves, female engineering and computer science students often navigated difficult relationships with their male peers. Being hindered from participating fully in team activities and being relegated to secretarial roles within teams were some experiences related by women in the study. Women spoke of "those guys who think they are better than you" but that female students "just have to work through it" and "figure it out" on their own or leave. In other words, to be successful, assimilation into the white, male culture of engineering is an underlying unspoken expectation.

One female professor admitted that faculty members do not pay close enough attention to the negative interactions that occur between the sexes in the classroom: "We could do a better job. When we hear those things, we do have to be a bit more proactive and we haven't been." There appeared to be an abdication of responsibility on the part of faculty members to deal with issues that fall outside of the academic realm but offer serious challenges to female students. Again, it appeared that the expectation was that either students will figure it out or leave. The lack of awareness displayed by male faculty members who refer to female students as "girls" most likely extends to a lack of awareness of how powerful the interactions between male and females in the classroom can be.

Comments from male students suggesting that females "get everything" because they are women, (including scholarships, internships, and job opportunities), are commonly heard by women in the programs. Women felt that much of the proving and testing they undergo occurs within their first two years as engineering students. By their junior years they feel they have been accepted and are integrated more fully into their degree program. In essence, they have passed the test.

Confidence in Abilities

For women in the study, difficulty of the course work combined with the feeling that they need to prove themselves can lead to issues of self-doubt. In interviews, women expressed not feeling as sure of themselves as their male peers appeared to be. Many struggle with achieving at a lower level than they have been used to in the past. Women in the study speculated that being underrepresented combined with losing confidence in

abilities when faced with a demanding academic program were reasons other women have left engineering degree programs.

Factors Specific to Persistence of Minority Engineering Students

Hispanic and Native American students were interviewed for this study. While attempts were made to recruit African American students for the study, none participated. As there are only seven active African American students across all degree programs, the lack of participation was not surprising. Hispanic students make up approximately 8% of students across the six majors while Native Americans make up approximately 14%. In terms of academic achievement, analyses of student records revealed that Hispanic students achieve at a level equal to that of their white peers while Native American students achieved at a lower level. Several factors related to persistence of minority students were surfaced through interactions with student in the study.

Integration Into Campus Life

For Native American students in particular, integration into the life of the university may pose unique challenges to overcome. For those who were preceded by a family member, the transition was not as disruptive. For students raised on the reservation where they were a part of the dominant culture, they enter an environment that is unfamiliar and become a part of a minority population.

Lack of Peers/Role Models

By nature of being "underrepresented" in engineering and engineering-related degree programs, minority students do not see themselves in the faces of their classmates. There are no Native American or African American members of the faculty and a single Hispanic professor. There was a Native American engineering faculty member in the past that was identified as a positive role model for native students, but he moved on to another university. For some students the lack of representation in both classrooms and faculty offices presents a challenge, for others it may confirm a sense of not belonging. Minority students felt the lack of diversity more acutely than do their professors. Faculty members tended to state that they did "not see differences" in ethnicity when they looked at their students; that they viewed all of their students as the same, i.e., engineering students. This is not to say that faculty members are unaware of the lack of representation of students of color, but that their view of equity is to "treat all students the

same." A typical statement from a faculty member was, "You know when someone walks in my class, probably the first day I sort of notice gender, ethnicity, whatever and then after that I couldn't care less. So I kind of don't even think about it in some ways."

Because of the lack of representation within engineering education, exposure to engineering environments that are more diverse than those they encounter within the university is essential. For some students, belonging to student organizations and attending national conferences of minority engineers, provided strong motivation for continuing in their degrees. Likewise, interning at large national corporations that were committed to increasing diversity allow students to see themselves in the faces of those with whom they may someday work. While the engineering workforce is far from being integrated, select experiences for students can reduce the isolation they experience as students and move them toward entering the workforce and in turn increasing its diversity.

Going hand-in-hand with the lack of representation of minority students is the lack of understanding of some of the white, male students as to why minorities should be given special programs or scholarships to help them attain their education. As one Hispanic student put it, "They don't understand why we need a helping hand." The student who said this came from an impoverished Hispanic community in southern California, an environment unknown and unknowable to many of her white peers. *Cultural Influences*

Upon entering the university, many Native American students not only enter a new academic environment, but also enter a new social paradigm. Many of the characteristics that are considered worthy of praise in the dominant white, male engineering student are antithetical to the way Native American students are raised. Drawing attention to oneself and one's accomplishments is socially unacceptable. Questioning those in positions of authority is equally so. While taking control of a group, and "jumping in" to solve a problem are valued in engineering students, for Native Americans learning is often a matter of standing back and observing before doing. Engineering faculty see the quieter nature of Native American students as a challenge to their persistence and express frustration that many of these students are reluctant to approach faculty members or seek help outside of class. When asked to picture their

most outstanding minority student and explain what it was that made them outstanding, faculty spoke of students who had the characteristics valued in white students such as assertiveness and overt leadership of a group. In essence, those students who had more readily assimilated into the dominant culture of the engineering classroom were those seen to be outstanding. So while engineering professors on one hand express the need for diversity in the engineering student body and profession, many often view the cultural characteristics that set minority students apart as "challenges to their success."

Cultural influences also affect the preferred learning styles of some of the students in the study. Native American students expressed that they are visual learners who need things to be presented in more modes that just as notes on a whiteboard. To these students, visual learning encompassed alternative means of expressing the information (diagrams, charts, pictures) as well as the need to interact with the material they were learning. This is often not the pedagogy they encounter in engineering and computer science courses. Faculty members are not unaware of the need for alternatives to traditional pedagogical approaches but many (although certainly not all) are reluctant to change and find alternative approaches uncomfortable. This is an issue that goes beyond engineering to all of the science fields in higher education.

The Multicultural Engineering Program

The remaining research questions guiding the study involved examining the Multicultural Engineering Program (MEP) as a source of support for underrepresented students in engineering:

- Do MEP components influence retention and graduation of minority students in engineering and engineering-related programs?
- Is the MEP meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?
- Are there unintended stakeholder antecedents, transactions, or outcomes associated with participation in MEP activities and services?

The evaluation of the MEP is intended as a formative evaluation and as such has the goal of informing program improvement (Scriven, 1967). While data informing on the effectiveness of the MEP was less abundant than for that related to underrepresented

student persistence, there are substantive findings that can be addressed. These will be summarized in the following sections.

Academic Achievement

The original goal of the MEP program was to "increase and enhance the academic performance and graduation rates of minority engineering students." It has been difficult to assess the degree to which MEP influences the academic achievement of minority students. Data from the pilot year of MEP showed higher GPAs in their first academic year, as compared to their peers, for students who participated in the first STAR-PALS summer bridge program. Current student GPAs are not significantly different for students who have participated in the PALS program than for their peers. It is important to note that the first PALS students were given a high degree of support in their first year including clustering, mandatory study groups, a skills course and access to support in the form of counselors for Native American and Hispanic students. Reduction in funds since program inception has done away with several of the sources of support provided to the first students supported by the MEP. While there were originally five funded staff members involved with the MEP, now there is one paid position, that of director. Fewer resources are now focused on more students who partake in MEP programs and activities. Increased academic achievement may be a less realistic goal for the current MEP program than is affecting student retention through supporting students of color through their degree programs. Better record keeping is underway for use of MEP services such as tutoring and peer-mentoring that may affect student achievement and this goal may be better addressed in the future.

Reducing Minority Student Isolation

While data related to academic achievement is limited, there is evidence to suggest that MEP does influence retention of minority students. Although not an intended outcome of the MEP, reduction of student isolation has shown itself to be an important function of MEP facilities and MEP staff. A high proportion of students of color, especially Native Americans, find in the MEP a place where they could come together for both social and academic purposes. Use of the MEP student lounge for studying, and meeting and making friends among their peers, provided students with a place where they can "see themselves" in the faces of other budding engineers. MEP

staff members provide academic as well as emotional support for women and minority students in the form of academic counseling, information on financial aid, and personal advice to help them through problems with faculty or other students. Students place a high value on support in the form of someone who knows them by name and is concerned about their progress. MEP offers this to students who may be reluctant for a variety of reasons, including cultural ones, to seek such support from their professors. MEP social functions offer students opportunities to connect with other students and with faculty and staff that can assist them through their academic careers. In helping students to connect with other students and with faculty members and support staff, MEP offers minority students ways to feel more integrated into the community of engineering at SPU.

Academic Support Programs

Both tutoring and peer-mentoring programs show promise in affecting student achievement and retention. Tutoring offered through the MEP is supplemental to that which is offered through the university's Learning Assistance Centers (LAC). MEP supplemental tutoring serves approximately 200 students per academic year on an individual or small-group basis. MEP sponsored tutoring is oriented toward small groups or one-on-one tutoring experiences. For many students this provides a more comfortable approach that gives them individualized help. MEP staff members help students to find peer tutors for classes not tutored through the LAC, and evidence indicates that tutoring services are utilized by non-minority students as well as minority, therefore providing a service to the greater engineering student community.

Students involved in the peer-mentoring program indicate that support from another engineering student is important to them in persisting in their degree programs. Having someone who has been through what they are experiencing is invaluable in helping students to integrate into the university and into their degree programs. Mentors found in the experience, a chance to "give back" to MEP for the support it had provided and a chance to give to new students the types of mentoring they would have liked to have received as they started their academic careers. Staff members saw the peer mentoring program as having a positive effect on student self-confidence and relationship-building among students.

Leadership

The current MEP director has proven adept at offering services to support underrepresented students on a shoestring budget. Leveraging funds from the Engineering Talent Pipeline project has allowed her to expand her "staff" (and therefore services) through the hiring of a graduate assistant and three student workers. New programs including a summer engineering camp for high school girls have expanded MEP's role in recruitment of underrepresented students into engineering programs. The MEP director is highly motivated to support women and students of color by offering both academic and personal support as they go through school. She connects with students and their families on a personal level that is not possible for many of the faculty members in the engineering programs, again offering that "someone who cares" as a source of support.

Concerns Related to the MEP

The two major areas of concern for the improvement of MEP are interrelated and provide a sort of "Catch-22" situation. Many students who are targets of MEP activities and services are not aware of what is offered by them in the way of student support. A student survey indicates that many students are interested in finding out more about what is available to them through the MEP but are currently unaware of the program. In addition, faculty members have varying degrees of understanding and therefore support for what MEP offers to students to help them persist in their academic programs. As one faculty member said, "I have the feeling that I don't really know a whole lot about MEP." There was a sense from several of the faculty members interviewed in the study that the MEP director is not communicating with faculty in an effective way for enhanced program effectiveness.

Raising the visibility of MEP services and successes would go far in reaching students who can use the extra support its programs offer. Better communication and increased interaction of the director with faculty members would alleviate two problems identified in the study: 1) the faculty members' lack of clarity as to the function of the MEP program and 2) the director's frustrations concerning faculty "buy-in" for MEP programs and services. However, without secured funding and the support of the

university's upper administration, increased awareness and understanding of MEP services could lead to a level of student use that is not sustainable. Current "staff" in the form of student workers has allowed for many of the programs to continue and begin growing. Securing funding beyond the end of the ETP grant is essential. From the perspective of faculty and the MEP director, upper administration at SPU has had little direct involvement in supporting the MEP program. The MEP director spends a great deal of time seeking funding and corporate support for programs. If the university seeks to present itself as valuing diversity in its' student body, then support for programs aimed at making underrepresented students more successful needs to be plentiful. Increasing staffing of the MEP would serve to alleviate the other concerns related to program effectiveness, allowing the current director to spend more time on effectively communicating program goals and services to faculty and students. Under a new dean and new development director, there appears to be a start to building a stronger relationship between MEP and college level administration. University level support should not be based on unquestioning acceptance of program effectiveness. The MEP director has the responsibility to continually evaluate her programs for the purpose of program improvement, and to communicate the findings of those evaluative efforts to the engineering faculty and college-level administration.

Interpretations in Light of the Literature

Findings of this study support much of what has been written regarding student persistence in higher education and specifically for underrepresented students in Science and Engineering degree programs. Support for Tinto's model of student integration (Tinto, 1993) is evident in interviews with successful underrepresented students in engineering degree programs. Participants in this study who have reached their junior and senior years are individuals who have experienced both social and academic integration into the university that has served to strengthen their goal-commitment of obtaining an engineering degree. Findings of this study reveal another layer of integration not found in the literature, i.e. integrating into the sub-culture of engineering education identified in this study as "learning the system." In this respect, students must learn (often with little external support) to navigate the structure of the engineering

discipline and to become successful learners within the context of often very traditional classroom pedagogies.

For minority students and first generations students, external factors such as family responsibilities and financial concerns play important roles in persistence. These factors put forth by Bean and Metzner in their Student Attrition Model (1985) seem to play a particularly important role for the students in this study. The findings of Cabrera, Nora and Casteneda (1993) that a student's intent to persist is the strongest indicator of actual persistence is well supported in this study. Underrepresented students in engineering and engineering-related degrees face multiple challenges to persistence including the lack of peers and role models, peer sexism, and pedagogical approaches that are not ideally suited to their learning styles. Successful students are those who persist in spite of the challenges (or perhaps because of them) and hold strong to the commitment of becoming an engineer.

Many of the factors identified as challenges to women and minorities in engineering surfaced in the findings of this study. Women face a "chilly climate" from the peers they work side-by-side with on a daily basis and from an overall environment in engineering education that requires them to assimilate into the dominant male culture or find another home. Engineering remains one of the least integrated of the sciences and women are still made to "prove themselves" in a field dominated by males. Once they do so they are accepted into the fold and go on to complete their degrees with a high level of success. For both women and minorities, the isolation that can come from being such a small portion of the student population may support decisions to switch from the major, one of the factors identified by Seymour and Hewitt (1997).

For Native American students who make up a large percentage of the minorities found in SPU engineering and engineering-related degrees, norms for the predominately white, male engineering culture are often counter to what they have experienced within their own cultures. The "quietness" of Native American learners is in contrast to their white, male peers who are enculturated to draw attention to themselves in the learning process. In writing of the importance of considering cultural contexts in science education for native students, Cajete (1999, p. 140) states that quietness is a "deeply embedded form of Indian interpersonal etiquette." According to Cajete, the school

environment is often a "cultural mismatch" for students and presents an emotional challenge to Native American students. Academic challenges can also come when pedagogical approaches are misaligned with the way students learn. While learning styles may vary within groups as well as across groups, research does support some generalizations for Native American learners. Native American students in this study report that they are visual learners who also need the chance to manipulate objects while learning. This finding is supported in the literature concerning Native American learners (Hilberg & Tharp, 2002; Morton, Allen, & Williams, 1994). This is in contrast to the way most engineering and computer science classes are structured where direct transmission of information is most often the norm.

Conclusions and Recommendations

As is the case with engineering programs across the United States, female and minority enrollment in SPU engineering and engineering-related degree programs is much lower than that of their White, male peers. Most students who switch from engineering degree programs do so either at the end of the freshman year or at the end of the sophomore year. Once beyond the threshold of the sophomore year, retention rates are high for all groups of students. Faculty speculate that loss at the end of the freshman year is due to students coming to realize that engineering is not the correct choice of a major for them due to lack of interest in the field and finding a better fit in another major. Loss of students at the end of the sophomore year may be from a combination of factors including the inability of the students to come to understand how to integrate into the engineering major and understand the system of engineering education. For underrepresented women and minority students, integrating into the system often means integrating into a culture dominated by the white, male instructors and peers. This study supports the greater body of literature on underrepresented students in the Science and Engineering fields in that women and minority students at SPU often experience the world in ways that are counter to the culture of engineering education. Emphasis on collaborative relationships, relevance to the greater societal good, and a tendency to hold back and observe before doing are a few examples of ways in which they tend to differ from their white, male peers. Conversations with successful female engineering faculty

revealed women who have integrated well into the dominant culture of engineering and hold similar expectations for those coming behind them. While diversity is valued by faculty members in engineering programs, integration into the culture is seen as the responsibility of students who must find their way within the bounds of long-standing traditions and practices. And those underrepresented students who most closely approximate the attitudes and behavior of the dominant white, male culture are often identified as being most notable by faculty members.

Underrepresented students who persist beyond their sophomore years are often exceptional individuals with the ability to make inroads into diversifying the engineering workforce. For underrepresented students, all possible effort should be made to support those who have found the right choice in an engineering or engineering-related field. SPU has the opportunity to make positive changes in retention of these special populations of diverse engineering students. Several factors point toward the potential to make an impact:

- Programs and class sizes are small, allowing for innovations in teaching and learning that are more difficult at a larger institution;
- Students have a positive perception of their relationships with faculty members, allowing for collaborative teaching/learning and mentoring partnerships;
- SPU engineering programs have a higher than average population of Native American learners, allowing for opportunities to bring these students together both within and outside the classroom, and
- SPU has in place a Multicultural Engineering Program whose purpose is to support underrepresented and first generation students in attaining their degrees.

In light of these factors and with the findings of this study in mind, recommendations to for improving the success of underrepresented students in engineering and engineering degree programs follow:

 All of the successful students in the study have established collaborative and supportive relationships with their peers. Faculty members who teach introductory engineering classes should facilitate the formation of study groups within their courses. Consideration should be given to making such groups a mandatory part of the curriculum in freshmen year classes.

- Faculty development is recommended that emphasizes differences in learning styles among all students with special attention to ways of adapting instruction and assessment to accommodate multiple ways of learning.
- Make overt the structure of "learning the engineering system." Identify
 successful strategies and ways of learning within the sub-disciplines of
 engineering and teach those to students early on in their academic careers. This
 should become a part of introductory classes in the sub-disciplines
- Faculty should consider the development of a course or program of study that
 emphasizes the global applications of engineering to the greater societal good. It
 would be beneficial to research programs and minors in Humanitarian
 Engineering that have been developed at other institutions including the Colorado
 School of Mines.

With respect to female and minority student success:

- Faculty members need to move beyond voicing support of women and minorities in the classroom to putting into practice teaching practices and interactions that foster success in these students.
- Faculty development is recommended centered around increasing the
 understanding of cultural influences on behavioral norms of Native students in the
 classroom. Attention should be paid to pedagogical applications of these
 understandings to benefit students who are not part of the dominant culture in the
 classroom.
- Faculty members cannot allow behavior in the classroom between male and
 female students that serves to marginalize women. It must be a clearly stated
 expectation that observed or related sexist behavior will not be tolerated and
 consequences for such behavior need to be clearly articulated.
- To alleviate issues related to marginalization of women and minority students by
 other students, efforts should be made to raise the level of awareness of
 engineering students as to the importance of and need for diversity within
 engineering fields. This could be done within the framework of a freshmen
 Orientation to Engineering course or within the introductory discipline-specific
 courses in the various engineering degree programs.

- To decrease the "culture shock" of female students whose numbers are
 particularly low in introductory engineering classes, consider ways of increasing
 the networking of female students. Consideration should be given to clustering
 women in introductory classes or finding other means to reduce their isolation
 until they begin to form supportive peer relationships.
- As a means of empowering underrepresented students, develop a way of gathering
 underrepresented student feedback on programs on a yearly basis. This could be
 accomplished through exit interviews with seniors and open-ended anonymous
 surveys that offer a way to gather in-depth information from students for program
 improvement. Until faculty listen to and recognize student concerns, change will
 not occur.

The MEP offers many valuable avenues of support of underrepresented students in engineering degree programs. The MEP offers a means of reducing the isolation of students of color by providing them with a place to come together and interact with peers through the use of the student lounge, social gatherings, and support of clubs targeting underrepresented engineering students. The MEP director and student staff offer personal support and guidance in an atmosphere that is comfortable and non-intimidating for students who may be less inclined to approach faculty members for advice and assistance. The MEP tutoring program reaches a large number of students per year and offers tutoring in a small-group or one-on-one environment that is more effective for some students than larger tutoring sessions and provides tutoring for classes not tutored through the university's tutoring centers. Peer mentoring offers a way for students to make the all-important peer connections identified by successful students in the programs. Under the current competent leadership offered by its director, the MEP has the potential to expand its services to recruiting efforts and K-12 outreach. In light of the findings of the study, recommendations for program improvement follow:

- The director needs to identify and clearly articulate MEP program goals with respect to the population targeted for MEP services and to share these goals with faculty and students.
- Continue data collection efforts related to levels of use of programs, and develop a means for collecting reliable student feedback as to program effectiveness

- To increase faculty buy-in to the program, develop more effective ways of communicating MEP activities and outcomes to engineering faculty. Increase faculty understanding of the services and programs offered through the MEP.
 This could be partially achieved through an informational meeting for engineering faculty during the week prior to the start of courses each fall.
- Provide to faculty and administrators a yearly report of MEP activities and programs. The report can inform on demographics and levels of use of MEP services and can offer evidence for program effectiveness. This will provide a means of synthesizing data collected over the course of the year, will raise faculty awareness of programs and services, and provide information for program improvement.
- To raise student awareness of MEP programs and services, consider classroom visits in introductory engineering courses at the start of each semester to inform students of the programs and services offered by the MEP.

At the level of the college:

- Currently student workers take on administrative tasks and provide coverage of MEP facilities in the absence of the director. Ability to sustain and expand programs and services is limited due to the lack of staffing. To increase the effectiveness of the MEP and to sustain its efforts, the university must commit to increasing permanent staffing beyond that of the director. Administrative assistant and assistant director positions would free much of the director's time for concentration on program improvement, sustaining current programs and exploring new and creative ways of recruiting and retaining underrepresented students in engineering.
- In turn, to maintain the support of the college, the MEP director has the responsibility to continually evaluate programs and services and eliminate those that do not show evidence of effectiveness.

At the level of the institution:

• As a part of its mission statement, the university cites diversity as one of its' values with it's goal to "achieve multicultural understanding as a priority of educational and civic life". Results of this study suggest that the university has

not gone far enough on a practical level to ensure that underrepresented students are supported in an effective manner and that their cultural differences are understood in the context of providing them with an equitable education. The university needs to more directly support programs such as the MEP that work toward retaining the students that are central to "achieving multicultural understanding."

Limitations of the Study

While multiple forms of evidence were presented to illuminate issues related to persistence of women and minorities in engineering degree programs, additional data would inform the research in greater depth. In this respect, limitations to the study include the following:

- Student interviews were limited to students currently enrolled in engineering degree programs and did not include those who have switched out of engineering into other majors;
- Women and minorities who are program graduates were not interviewed for the study;
- Although present in the responses to the on-line student survey, the white, male student perspective to underrepresented student persistence was not addressed through in-depth interviews, and
- While particular attention was paid to cultural competence in the study design, the
 researcher is not a member of a minority group and therefore student responses to
 interview questions may have been tempered in a way that they would not have
 been had the interviewer been a member of their ethnic or cultural group.

Need For Further Study

Related to the limitations of the study, several avenues for further research are suggested. Attempts were made early in this study to identify underrepresented students who had left engineering degree programs with little success. Current efforts are being made to better track students who have left degree programs within the university and

switched into other programs. It would be very beneficial to inform on issues of persistence to find out why underrepresented students leave engineering programs at SPU. Several hypotheses were raised by faculty members and students in this study that could be tested through such efforts and could inform on ways to improve programs for those who choose to stay. Successful SPU underrepresented engineering graduates could offer a unique perspective on issues related to the persistence of those following behind them. They could also contribute the perspective gained through participation in the engineering workplace to inform on what is needed in helping underrepresented students to persist.

Conclusion

Underrepresentation of women and minority students in engineering education programs and in the engineering workforce is an issue which has global implications in a world that is becoming smaller due to advances in technology and communications.

After decades of research and programmatic innovations related to the lack of diversity in S&E fields, engineering in the United States remains one of the least integrated fields of the sciences. Insights into reasons for the continued lack of representation are paramount to changing the landscape of the engineering workforce.

This study has helped to illuminate ways in which women and minorities are supported and challenged in their academic pursuits in engineering programs at a mid-sized university in the southwestern United States. Many of the issues that surfaced in the study support much of what has been written in the literature related to underrepresented students in Science and Engineering programs. Where the study offers it's most significant contributions is in contextualizing the findings to the institution under study and offering data on which to base programmatic improvements.

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APPENDICES

Appendix A: Letter to Engineering Faculty

To: Engineering faculty and staff

From: Carol Haden, Project Evaluator, Engineering Talent Pipeline Project

Re: Proposed study of underrepresented students in engineering degree programs

I have been working for the past year with faculty and staff involved in the Hewlett ETP project. As part of my work as an evaluator for the ETP project, I am proposing to conduct a study examining factors that enhance or hinder students in completing engineering, computer science or construction management programs here at (university), with special attention to underrepresented women and minority populations. In addition to supporting my work as the project evaluator for the ETP grant activities, this study will also be the substance of my dissertation work for a doctorate in education. The guiding questions for this study are as follows:

- 1. What are the population demographics of students in the engineering degree programs and how do they compare to (university) and nationwide demographics?
- 2. What factors enhance or hinder successful retention and graduation of engineering students, (with special attention to underrepresented students)?
- 3. Which processes, programs, or activities are most effective in enhancing retention of underrepresented students?

I am proposing to answer these questions through a variety of data sources:

- Individual student interviews
- Student focus group interviews
- Faculty and staff interviews
- Document analysis

It is my hope that this work will be beneficial to the engineering faculty and staff in helping to provide information on ways to support all students, especially women and minorities within your degree programs. An evaluation study should be designed to address the needs of the stakeholders in a program, in this case you as faculty and staff, as well as students enrolled in your programs. Therefore, I would greatly appreciate any questions, comments or input you might have on the proposed scope of work.

Thank you,

Carol Haden
Center for Science Teaching & Learning

Appendix B: Evaluation Matrix

Evaluation Matrix

Subquestion	Data collection	Data analysis	Schedule
What social integration issues within the university influence minority students in being successfully retained in engineering programs at SPU?	Student focus group interviews Individual student interviews Faculty/Staff interviews	Content analysis through open and axial coding	Pilot- Spring '05 Faculty Interviews – Summer '05 Student Interviews- Fall '05
What academic integration issues within the university influence minority students in being successfully retained in engineering programs at SPU? What factors external to the university influence	Student focus group interviews Individual student interviews Faculty/Staff interviews Student focus group interviews	Content analysis through open and axial coding Content analysis through open and	Pilot- Spring '05 Faculty Interviews – Summer '05 Student Interviews- Fall '05 Pilot- Spring '05
minority students in being successfully retained in engineering programs at this university?	Individual student interviews Faculty/Staff interviews	axial coding	Faculty Interviews – Summer '05 Student Interviews- Fall '05
How do minority students who utilize MEP program components compare academically to minority students who do not utilize MEP program components?	University student database Student transcripts	Univariate Statistical Analysis	Summer 2005
How do students who utilize MEP program components compare to minority students who do not utilize MEP program components in terms of satisfaction with their degree programs?	Student focus group interviews Individual student interviews Faculty/Staff interviews	Content analysis through open and axial coding	Pilot- Spring '05 Faculty Interviews – Summer '05 Student Interviews- Fall '05
Is the MEP program meeting its intended goals and outcomes in support of minority students in engineering and engineering-related degree programs?	Student focus group interviews Individual student interviews Faculty/Staff interviews Program Documents University student database	Content analysis through open and axial coding	Pilot- Spring '05 Faculty Interviews – Summer '05 Student Interviews- Fall '05
Are there unintended stakeholder antecedents, transactions or outcomes associated with participation in MEP program activities and services?	Student focus group interviews Individual student interviews Faculty/Staff interviews Program Documents	Content analysis through open and axial coding	Pilot- Spring '05 Faculty Interviews – Summer '05 Student Interviews- Fall '05

Appendix C: Engineering Student Web Survey

http://www.surveymonkey.com/SurveySummary.asp?SID=1435940&Rnd=0.925015

In an effort to improve services for engineering, computer science, and construction management students that are intended to support them in completing their degrees, we are asking you to take a few minutes to complete the following survey. Your input will be greatly appreciated and will help to improve programs for you and for future students. Thank you for participating.

1.	Please	enter your gen	der	
		Female□	Male	
2.	Please	select your eth African Amer Asian Americ Hispanic Native Americ White International	ican an	(Check all that apply) askan Native
3.	What i	18 – 22 23 – 28 29 – older		
4.	_	ou a first genera e or university) Yes		llege student (neither parent attended a four-year No
5.	Are yo	ou a transfer stu Yes	dent?	No
6.	Do you	u live on or off On Campus	campu	s? Off Campus
7.	Are yo	ou an in-state or In-state	out-of	-state student? Out-of-state
8.	What i	Freshman Sophomore Junior Senior Graduate stud Post-baccalau	ent	

		Post-degree certification student
9.	What i	s your major? Electrical Engineering Environmental Engineering Civil Engineering Mechanical Engineering Computer Science Construction Management Master's in Engineering
10.	If you	have a dual major please specify your other major.
11.	How	familiar are you with the Multicultural Engineering Program (MEP)? I've never heard of it I've heard of it but I don't know what they do. I know of it but choose not to participate. I participate in MEP activities and/or services.
12.	-	ou participate in the PALS summer bridge program prior to ning your degree program? Yes No
13.	Whice	ch MEP services do you utilize? (Check all that apply) I do not use any MEP services. Tutoring/AES (this does not mean LAC tutoring) Peer mentoring (as a mentor or mentee in MAPP) Supplemental Advising Supplemental scholarship information (other than engineering scholarship office) Social events Informal contact (e.g. stopping by to chat, personal support) Other (please specify)
14.	Which	MEP services would you like to know more about? (Check all that apply) Tutoring (AES) Peer mentoring (MAPP program) MEP social events Supplemental scholarship information Supplemental advising
15.	What o	campus-wide support services do you utilize? (Check all that apply) Learning Assistance Center (LAC) tutoring Native American Student Services Multicultural Student Center Student Support Services

	 □ Counseling and Testing Center □ Gateway Center □ Career Services □ Other (please specify)
16.	On a scale of 1 to 5, with 1 being "UNIMPORTANT" and 5 being "EXTREMELY IMPORTANT", rate the following as to how important they are as sources of support as you are working toward completing your degree. 1 2 3 4 5
	Family emotional support Family financial support Peer study groups Peer social interactions Faculty member(s) Student Loans Scholarship(s) Internship(s) Career counseling Engineering clubs or societies Multicultural Engineering Program staff Multicultural Engineering Program tutoring (AES) Learning Assistance Center tutoring
17.	Are there any other sources of support that are or have been important to you in helping you to complete your engineering, computer science or construction management degree? Please specify.
18.	Are there sources or types of support that would be helpful to you that are not currently offered? Please specify.
19.	What is the best way to get information to you regarding engineering activities, events or services? (Check all that apply Email Flyers in hallways In-class announcements Mailing Other (please specify)

Thank you for your participation!

Appendix E: Faculty Interview

My name is Carol Haden and I work with the Center for Science Teaching and Learning. I am working as the project evaluator for the Hewlett ETP grant and am evaluating the MEP program as well as examining factors that influence retention of minorities and women in engineering. This is also the focus of my own dissertation research.

The purpose of this interview is to help identify factors that contribute to or hinder minority students from completing their degree programs in engineering and engineering-related sciences. As a part of this study I am interviewing students, faculty and staff to gain a better understanding of underrepresented students in engineering degree programs and how they are supported to continue their studies. I want to be clear in telling you that these interviews or other project-related data collection are not in any way intended to evaluate the performance or merit of individual faculty or staff members.

I will be asking you questions about your experiences with minority students in engineering classes and programs. Your privacy and confidentiality will be upheld in this study. While the interview will be audio-taped, your name and any comments you make will remain confidential, and no identifying information will be used when findings are shared with other engineering faculty or staff in the form of a report. Information from this interview will be kept securely in my possession. No one but me will have access to the notes or audiotapes and they will be destroyed at the end of the study.

If, during the course of our interview, you feel uncomfortable in any way by the discussion, you may stop your participation immediately. Do you have any questions about this study that you would like to ask me before we begin?

Ouestions:

- 1. In general, what do you feel are characteristics of students that make them successful in pursuing engineering and engineering-related degrees?
 - a. Why are these essential characteristics?
 - b. How do successful students differ from those that are not successful?
 - c. Any other factors that influence student success?
- 2. What do you see as the major challenges to any engineering student that might prevent them from completing their degree programs?
 - a. Why do you think this is so?
 - b. Any other challenges that you have noticed?
 - c. Can any of the challenges you have mentioned be overcome? Tell me more about this.
- 3. Tell me about your experience in teaching minority students in engineering or engineering-related degrees.
 - a. Are these experiences different from your experiences with non-minority students?
 - b. Can you elaborate?

- 4. Have you ever mentored a minority student who was considering leaving their degree program or the university?
 - a. Can you tell me about the experience?
 - b. What were the issues that were challenging the student?
 - c. Are there any other factors that make the process challenging for minority students?
- 5. Think back to the most outstanding minority student you have taught or mentored.
 - a. Describe the student and tell me what made them stand out for you.
 - b. Can you tell me more about this?
- 6. From your perspective, what are the differences in learning styles (if any) between minority and non-minority students?
 - a. Can you give an example of this?
 - b. Has your teaching changed as a result of having minority students in the classroom?
- 7. What sorts of extracurricular support programs for minority students are you involved in (if any)? (prompts: sponsor clubs, participate in undergrad research opportunities for minorities)
 - a. If yes, what has this experience been like for you?
 - b. What have you learned from working with these students?
- 8. Tell me what you know about the Minority Engineering Program.
 - a. Do you inform students in your classes of the services that MEP offers in tutoring and mentoring?
 - b. If yes, what do you tell students about MEP?
- 9. How effective do you think the MEP program is with respect to retaining minority students?
 - a. Are there things that the MEP is doing well?
 - b. If you could change one thing that the MEP does, what would that be?
- 10. If you had one message for the powers that be concerning improving minority student retention in engineering, what would that message be?

Thanks you for your willingness to talk with me today. Your input has been very valuable to the study. I will provide a report to engineering faculty and staff with the findings from this study.

Appendix F: Student Interview

My name is Carol Haden and I work with the Center for Science Teaching and Learning. I am working with the engineering faculty and staff to help them evaluate courses and programs offered through the College of Engineering and Natural Sciences.

The purpose of this interview is to help the engineering faculty and staff to identify the ways in which underrepresented students have felt supported to continue their degree programs in engineering, and ways that they might improve work with students to make their educational experience better and more rewarding. This study is a part of my dissertation for a doctoral degree in education.

I will be asking you questions about your experiences as a student in engineering classes and programs. Your privacy and confidentiality will be upheld in this study. While the interview will be audio-taped, your name and any comments you make will remain confidential, and no identifying information will be used when findings are shared with engineering faculty or staff. Information from this interview will be kept securely in my possession. No one but me will have access to the notes or audiotapes and they will be destroyed at the end of the study.

I want to reassure you that there is no risk to your grades or graduation status by participating in this interview. If, during the course of our interview, you feel uncomfortable or in any way stressed by the discussion, you may stop your participation immediately. Do you have any questions about this study that you would like to ask me before we begin?

Student degree program	Academic level

- 1. What brought you to NAU to pursue a degree in (<u>student's degree program</u>)? Probes: How did you hear about NAU Engineering? What attracted you to your degree program?
- 2. Tell me about being student in engineering.
 - a. What about the engineering environment makes it comfortable? Uncomfortable?
 - b. Please tell me more.
- 3. Are your engineering classes different in any way from your non-engineering classes? (prompts might include, style of teaching, quality of teaching, interaction with professors, workload, competition)
 - a. If yes, how are they different?
 - b. Can you explain it in another way?
- 4. What kinds of support have been most important to you while working on your engineering degree?
 - a. Are there other types of support that have helped you along the way? (prompts might include: study groups, mentors, financial aid, career counseling, family)
 - b. What types of support would be helpful to you that you are not getting?

- c. Is there anything else?
- 5. What have been the toughest things you have had to overcome while working on your degree?
 - a. Are there any other factors that have made the process challenging?
 - b. Have there been times when you have considered leaving the university or changing majors? If so, why?
- 6. Tell me about your experiences in engineering classes (pre-engineering classes).
 - a. Have you felt comfortable in the classroom? Tell me more.
 - b. Describe a time when you felt uncomfortable in an engineering class.
 - c. Describe an experience that made you feel especially comfortable in an engineering class.
- 7. What is the experience like for minority (or female) students in engineering?
 - a. What role do faculty and staff play in this experience?
 - b. To what extent are professors supportive, if at all?
 - c. To what extent are professors non-supportive?
- 8. Do you know of other minority (or female) students who have left engineering degree programs?
 - a. If yes, why do you think they left?
- 9. Has your experience as an engineering student been what you expected it to be?
 - a. Before starting your program, what did you think it would be like?
 - b. Is that different from how it really is?
 - c. What has surprised you about your experiences as an engineering student?
- 10. If there was one message you wanted to send to those who run the engineering programs, what would that message be?

Thank you very much for your willingness to talk with me today. Your contribution to this project will help to make improvements in the experiences of students who come after you.

Appendix G: MEP Program Director Interview

- 1. Please tell me about your role as Director of the Program.
 - a. What drew you to this position?
 - b. What are the things you most love about your job?
 - c. What are the most frustrating aspects of you job?
- 2. What kinds of services does the MEP program offer to students?
 - a. Who is responsible for the individual services?
 - b. How are these services meant to support underrepresented students?
- 3. How are students selected and/or recruited into the MEP program?
 - a. Is this the way it was always done?
 - b. Are there things you would like to do differently with respect to recruiting students into MEP programs or support services?
- 4. How does the program function?
 - a. What staff roles support the program?
 - b. What additional support do you need from engineering faculty/administration/staff?
- 5. What do you see as the main challenges to minority students in completing their degree programs in engineering?
 - a. Why do you think this is so?
 - b. Any other challenges that you have noticed?
 - c. What role does MEP play in alleviating these challenges?
- 6. What characterizes a successful underrepresented student in engineering?
 - a. Why are these essential characteristics?
 - b. How do successful students differ from those that are not successful?
 - c. How does MEP help students toward being successful?
- 7. What are ways that you and the MEP staff support underrepresented students that aren't part of the documented work of the MEP program?
 - a. Prompts: emotional support, role models etc
- 8. What MEP services do you see as being the most successful in helping to retain underrepresented students?
 - a. Why do you think these are most successful?
- 9. What MEP services would you like to see improved?
 - a. What ideas do you have for improving these services?
- 10. If you had one message for the powers that be concerning increasing underrepresented student retention in engineering, what would that message be?

Appendix H: MEP Staff Interview

- 1. Please tell me about your role as a student worker for the MEP program.
 - a. What sorts of things do you do in your day to day job?
 - b. What drew you to this position?
- 2. What is it like working in the MEP office?
 - a. What are the things you most love about your job?
 - b. What are the most frustrating aspects of you job?
- 3. What MEP services do you see as being the most successful in helping to retain underrepresented students?
 - a. Why do you think these are most successful?
 - b. Which services do students most frequently seek out from the MEP office and staff?
- 4. What MEP services would you like to see improved?
 - a. What ideas do you have for improving these services?
- 5. What are ways that the MEP staff support underrepresented students that aren't part of the documented work of the MEP program?
 - a. Prompts: emotional support, role models etc
- 6. What do you see as the main challenges to underrepresented students (the students you see as part of your work in MEP) in completing their degree programs in engineering?
 - a. Why do you think this is so?
 - b. Any other challenges that you have noticed?
 - c. What role does MEP play in alleviating these challenges?
- 7. What are ways that the MEP staff support underrepresented students that aren't part of the documented work of the MEP program?
 - a. Prompts: emotional support, role models etc.
- 8. What is your role during the PALS summer bridge program?
 - a. How does the program function?
 - b. What is your perception of how the summer bridge program is doing with respect to supporting future engineering students? What do students walk away with after participating in PALS?
 - c. What are the strongest parts of the PALS program?
 - d. What parts of the PALS program do you see needing support or improvement?
- 9. What MEP services would you like to see improved?
 - a. What ideas do you have for improving these services?

would that message be?

10. If you had one message for the powers that be concerning the MEP program, what