Recruiting and Retaining Women and Minorities in Public Sector Engineering Positions

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Executive Summary

Phase One

The objective of phase one of this research was to assess the degree to which currently employed Iowa Department of Transportation (DOT) employees would be affected by a more aggressive policy to recruit and retain women and minority engineers. The DOT's *Future's Agenda* was used as a baseline to focus on efforts to update and implement a recruitment plan that would target underrepresented classes.

The primary question that emerged out of phase one was how could the Iowa DOT strengthen its ties with Iowa State University (ISU) to produce increased numbers of in-state applicants for engineering positions. This introduced the objectives of phase two.

Phase Two

The objective of phase two of this research was to identify problem areas resulting in unacceptably high attrition rates for women, minorities, and to a lesser degree, Caucasian men in the College of Engineering at ISU, particularly Civil and Construction Engineering (CCE). Past research has focused on (1) projected shortages of qualified civil engineers, (2) the obstacles confronting women in a traditionally male-oriented profession, and (3) minorities who are often unprepared to succeed in the rigors of an engineering curriculum because of a lack of academic preparedness. The researchers in this study, in contrast, chose to emphasize institutional reasons why women, minorities, and some Caucasian men often feel a sense of isolation in the engineering program.

It was found that one of the key obstacles to student retention is the lack of visibility of the civil engineering profession. The visibility problem led to the hypothesis that many engineering students do not have a clear conception of what the practice of civil engineering entails. It was found that this may be a better predictor of attrition than the stereotypical assumption that a majority of students leave their engineering programs because they are not academically able to compete.

Recommendations are offered to strengthen the ties between ISU's Department of CCE and the Iowa DOT in order to counter the visibility issue. It was concluded that this is a vital step because over the next 5-15 years 40% of DOT engineers currently employed will be phasing into retirement. If the DOT expects to draw sufficient numbers of engineers from within the state of Iowa and if increasing numbers of them are to be women and minorities, a university connection will help to produce the qualified applicants to fulfill this need.

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Chapter I

Introduction, Objectives, and Background Information

Objectives

Phase One Objective

The primary objective of phase one of this research was to assess the degree to which currently employed Iowa Department of Transportation (DOT) employees would be affected by a more aggressive policy to recruit and retain women and minority engineers. The DOT's overall workplace objective is to continue to attract and retain highly qualified engineering personnel. As a part of that objective, according to DOT administrators. implementation of a formal diversity policy will be important in order to remain competitive into the twenty-first century.

The attitudes and opinions held by DOT personnel will be important in thoroughly evaluating the direction of the changes likely to be implemented during the coming years. Therefore, one of the foci of this research was to assess the work climate that could emerge if there were a sudden and noticeable increase in the numbers of women and minority engineers at the DOT, including such factors as employee morale, productivity, and efficiency that were viewed as integral to considering internal changes in the work force.

Rationale for Phase One Objective.

The DOT's progressive commitment to diversity represents a recognition that a shift in workforce demographics will occur at the Iowa DOT. The agency's plans are to

> update and implement a recruitment plan to target hiring for classes in which recruitment and retention are concerns, as well as classes which are under-utilized for women and/or minorities in specific geographic areas.[1]

It will be challenging to achieve this objective in a state that is predominantly Caucasian and where an overwhelming majority of the state's Registered Professional Engineers (P.E.s) are male. At the time the first phase of this study began in 1992, there were 2,373 registered Professional Engineers residing in the state of Iowa who were male and 40 who were female. Numbers of minority P.E.s were unavailable; however, one African American P.E. was employed with the

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[1] Iowa Department of Transportation. (1991). *Future's Agenda*, p. 17.

DOT as of December 1993. Of the 40 women P.E.s, 7 were employed with the DOT. An additional 7 were employed as Engineers in Training (E.I.T.s). These numbers raise many issues for DOT administrators, two of which are (1) whether the DOT should be expected to hire male, female, and minority engineers in numbers proportional to the numbers of state-registered P.E.s in each category,[2] and (2) if this is not possible using in-state recruiting methods, whether the DOT should then aggressively recruit from outside the borders of the state of Iowa to achieve a gender and racial diversity balance. A third issue, following from phase one recommendations and addressed in phase two of this study, was to consider factors that would lead Iowa State University (ISU) to increase its retention rate for women and minority engineering students and thus expand the available pool of engineers from which agencies such as the Iowa DOT could recruit. The DOT administrators are united in their philosophy that "to remain competitive in hiring and retaining employees in the future, the agency must adapt its processes now so that all employees are recognized as valuable resources that must be carefully managed, developed, challenged, and rewarded."[3] Transportation researchers agree this will necessarily include working toward a gender and racial balance in the work place.[4]

John Alexander, Chair of the Department of Civil Engineering at the University of Maine concurs. He says, "if the civil engineering profession does *what it should*[5] to attract and retain women and minorities, *we* should have a more balanced profession by the year 2000."[6] In any concerted effort to attain this balance, it will be important to recognize that "agencies appearing to be open and progressive will be better able to compete for the growing source of professional skills presented by women and minority engineers."[7] Increased levels of competition due to higher numbers of applicants for positions may well help to control for the negative images many

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2 i.e., these categories are Caucasian male, women, and racial minorities.

3 See Iowa Department of Transportation (1991), p.17.

4 Foley, D. (1994). Human-resource management for twenty-first century: managing diversity. *Journal of Professional Issues in Engineering and Practice, 120(2),* pp. 121-128.

5 Emphasis added.

6 Alexander, J. (1991). Professionalism and marketing of Civil Engineering Profession. *Journal of Professional Issues in Engineering Education and Practice, 117(1),* p. 16.

7 State Highway Agencies. (1985). *Transportation Professionals: Future Needs and Opportunities: A Study of Transportation Professional Needs for Highway and Mass Transit Agencies in State, Local and Federal Government,* Transportation Research Board, National Research Council, Washington D.C., p. 81.

employees hold of affirmative action as a preferential hiring mechanism mandated by the federal government.

The diversity charge to the Iowa DOT will be a challenge because the civil engineering profession has not traditionally attracted large numbers of either women or minorities. The profession's male image continues as a primary factor discouraging women, while minorities face additional barriers, both social and educational. One civil engineering university advisor who was interviewed commented that many minority students are coming back and saying

> in many cases, although certainly not all, you have to be twice as good as your white counterpart in order to make the same type of promotions. We get the feeling that we are not allowed to be average--we have to be sensational.[8]

It is clear that DOT administrators in charge of factoring racial and gender diversity into the agency's Future's Agenda have a vested interest in evaluating how plans to implement such a policy will affect current employees in the various divisions, bureaus, offices, and districts.

Phase Two Objectives.

The objective of phase two of this research was to identify problem areas resulting in an unacceptably high attrition rate for women, minorities, and to a lesser degree, Caucasian males in the College of Engineering, particularly Civil Engineering at ISU.[9] The sample used for this research was drawn from the Engineering College as a whole because the numbers of women and minority students within the Department of Civil and Construction Engineering were too small for a meaningful analysis of the data. Caucasian men were included in the study because it is important to compare, contrast, and evaluate the differences in retention rates among these three groups. Moreover, a sample of students who have left the College of Engineering to pursue majors in other Colleges and departments at ISU were also included in this study. The objective of including these individuals was to gain a better understanding of why students actually leave the College of Engineering. A further explanation and rationale for this selection process will be presented in the Methods Chapter of this report.

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8 Asbrand, D. (May 29, 1986). Efforts to draw minorities to engineering make progress but still face obstacles. *EDN, 31,* p. 259.

9 For both men and women students that rate is approximately 50%. Eighteen point six percent of currently enrolled students in the Department of Civil and Construction Engineering at Iowa State University are women, while 4.8% are racial minorities (ISU College of Engineering).

Rationale for Phase Two Objectives.

Nationwide, approximately 50% of men and women who begin their studies in engineering actually complete their degrees in this field. Even for those who do complete their studies, nearly 20% do not pursue careers in civil engineering. For minorities the attrition rate nationwide is even higher, at 80%.[10] Continued high attrition rates for these underrepresented groups have helped to reify their relatively low numbers in the engineering sector[11] and some researchers have concluded that the participation rates of women and minorities are not likely to increase significantly by the year 2000. Even aggressive policies to achieve diversity will generate only slow changes in the demographic composition of the work force. Schneider notes, for example,

> even substantial changes increases in the rate of entry of blacks and women into the engineering labor force will yield minimal changes in their penetration of the labor force because of the dominant position occupied by white males. The achievement of a 2-fold increase in the number of engineering degrees awarded to women and blacks by 1985 would, on the average, produce a pool of new entrants to the engineering labor force that would be 85% white male and 15% women and blacks.[12]

Schneider's findings provide some evidence that a proactive approach to achieving a diversity balance is important. One reason for this is that if transportation agencies are going to be successful in the twenty-first century,

> it will be because they are able to provide individuals who can adapt to the rapid changes that are foreseen <u>and</u> unforeseen. With proper education, motivation, and research, the tools will be available for these new professionals to address the exciting challenges of the future. The net result will be transportation engineers who are masters of their destinies and who fulfill a role that addresses the needs of society at the highest level.[13]

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10 Landis, R. (May 1988). The case for minority engineeing programs. *Engineering Education,* pp. 756-761.

11 That is, for minority students, if 70% of 12 students (8 students) leave their civil engineering programs prior to graduation, the loss is more keenly felt than if that number is 50% of 700 (350 students).

12 Schneider, Stephen A. (1977). The Availability of Minorities and Women for Professional and Managerial Positions: 1970-1985. *Manpower and Human Resources Studies No. 7.* University of Pennsylvania, p. 61.

13 ITE Technical Council Committee 2-32. (January 1990). Attracting Students To a Professional Career in Transportation Engineering. *ITE Journal*, p. 47.

Background Information

The Iowa State University and Iowa Department of Transportation Connection

If the Iowa DOT is to maximize its opportunity to hire competitively from the ranks of qualified in-state engineering graduates (including Caucasian male, women, and minorities), the hypothesis is that it will need to develop stronger ties with the universities that provide these entry-level employees. Agency and university ties are important because

> the normal practice in most states is for agencies to hire relatively inexperienced entry-level engineers, train them in the varied activities of the agency, and promote them after several years to fill higher staff positions within the organization.[14]

This hiring philosophy not only provides agencies with a stable supply of engineers but also establishes career paths for young engineers that serves to foster loyalty to the agency and that may serve also to discourage high rates of attrition.[15] It may also help the Iowa DOT to avoid the problem of finding an adequate pool of qualified applicants. As the Transportation Research Board (TRB) Special Report stated,

> The pending surge in retirements and replacements will occur simultaneously in many states, so that a strategy of simply looking farther afield for new candidates will not be as effective as it has in past years, when peak professional needs were confined to only a few scattered states.[16]

In a sense, recruiting in-state will allow the Iowa DOT to hire employees who may have a vested interest in the state of Iowa. The university is an excellent training ground and a solid source for DOT employee recruitment, in part because 75% of transportation professionals in state transportation agencies nationwide are products of university civil engineering programs.[17] Given the growing need for rehabilitation and maintenance of Iowa's infrastructure as well as the increasing importance of traffic engineering, traffic safety, and environmental and ecological concerns, the DOT should expect to continue with its policy of hiring recent university graduates for entry level engineering positions. This assumption is consistent with the American Association of State Highway Transportation Officials' (AASHTO) finding that it is likely that, nationwide,

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14 Transportation Research Board. (1985). *Transportation Professionals: Future Needs and Opportunities. TRB Special Report 207.* Washington, D.C.: TRB.

15 *Ibid.*

16 See Transportation Research Board (1985), p.79.

17 *Ibid.*

state transportation agencies will likely maintain their 17% market share of civil engineers,[18] providing an impetus for the Iowa DOT and its feeder university (in this study, ISU) to (1) consider its recruitment policy for attracting qualified civil engineers, and (2) to emphasize the vested interest the DOT has in the university's retention record for engineering students, the focus of phase two of this study.

The Challenge

In the coming decade, attracting a diverse pool of engineers into public sector engineering positions may be one of the most challenging issues confronting both state DOTs and universities. In a national study, AASHTO states that during the 1990s, the number of women entering the work force is expected to continue to increase.[19] The AASHTO report noted, however, that the civil engineering profession's male image continues as one of the factors discouraging many women from pursuing career tracks in transportation engineering. Even when women earn top grades in high school, they are frequently steered away from engineering by some high school counselors who show little encouragement to young women expressing an interest in an engineering career. In an interview conducted by researchers working on a 1990 National Science Foundation (NSF) sponsored grant, one civil engineering faculty member commented, for example,

> Some of those whose job it is to advise students on career opportunities are perpetuating the myth that women, at least, should train for "appropriate" careers such as secretarial jobs and nursing.[20]

According to a 1989 survey of women engineers, "80% said the main reason for the relatively low numbers of women entering the profession is the failure of counselors to encourage talented young women to pursue engineering careers."[21]

Another problem is that many women believe they will be faced with the problem of isolation in civil engineering programs. The perception is that "to be a woman engineering

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18 The American Association of State Highway Transportation Officials. (1990). *The American Association of State Highway Transportation Officials Guide to Recruitment and Retention of Civil Engineers.* AASHTO, p. 33.

19 See AASHTO, p. 90.

20 Meade, J. (September 1991). The missing piece. *ASEE PRISM*, p. 20.

21 *Ibid.*, p. 20.

student (an issue for universities to address) or professional (an issue for the Iowa DOT to address) is to isolate oneself from the world of women."[22]

One of the hypotheses has been that both the university and the DOT could dispel some of these perceptions with increased levels of student contact, possibly in the form of formalized student study or project groups that encourage Caucasian male students to interact more intensively with their peers who are members of underrepresented groups. One African American student who participated in this study commented, however, that finding lab partners for her engineering courses was difficult because she was the only minority student in the class, and no other students seemed to think of asking her to work with their group.

Another hypothesis has been that opportunities for mentoring relationships with university faculty and DOT co-op experiences and internship opportunities will enhance retention for minority students in particular and for all students in general. Those students who have participated in such experiences, speak highly of the challenges and opportunities to which they are exposed. Of particular interest are those experiences that allow an inside glance at what it means to practice engineering. Such experiences would also serve to alleviate some of the perception that engineering is a self-isolating program. Some students, for example, hold the perception that such isolation in their roles as students will carry over into their roles as professionals. As a result, they believe this isolation might limit employment enhancement opportunities.[23]

The desired diversity balance proposed by Alexander may also be difficult to achieve if, as Vetter concludes, "women's interests in pursuing degrees in engineering are currently declining and without an active effort this situation is not likely to reverse itself."[24] In general, "student interest levels in the repair or replacement of the infrastructure, even to upgrading standards, is usually far less than that ascribed to addressing new construction or the allure of the private sector."[25] The lack of student interest in civil engineering remains a major concern for employers

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22 Fulco, N. and Dallaire, G. (May 1973). Are more women needed in engineering. *Civil Engineering-ASCE*, pp. 56; Robinson and M^c^Ilwee. (1989). Women in engineering: a promise unfulfilled? *Social Problems, 36(5).*

23 Comment made by an engineering student. See also Robinson and M^c^Illwee.

24 Mason, J., Tarris, J., Zaki, E. and Bronzini, M. (Consultant). (1992). *National Cooperative Highway Research Program Report 347: Civil Engineering Careers, Awareness, Retention, and Curriculum.* Transportation Board National Research Council, p. 5.

25 Corotis, R. and Scanlan, R. (1989). Future of civil engineering profession and the role of education. *Journal of Professional Issues in Engineering, 115(2)*, pp. 117-125.

of transportation engineers. Moreover, it is not only women whose interests in civil engineering are waning. A 1992 article in the *Transportation Educator's Newsletter* reported that the interest of engineering graduates in transportation careers has generally decreased.[26] Another 1992 study sponsored by the National Cooperative Highway Research Program (NCHRP) concluded that the remedy will require a long-term continuous effort.

In preparation for the new millennium, state transportation agencies must begin to develop mechanisms by which they can more effectively compete for engineers.[27] Civil engineering, for example, has "neither publicized--nor glorified, if you will--its many achievements."[28] The dual inhibitors of "low public sector salaries" and lack of "professional glamour" or status remain problematic. Civil engineering contributions are not highly visible. This leads to less of an understanding about the profession. As it will be shown in more depth in the Results and Discussion Chapter of this report, students in engineering programs at Iowa State University frequently comment, "as students we had hoped we would have learned more about what the engineering enterprise has to offer us." Low visibility and low perceived status and low salaries are factors that can no longer be ignored. The visibility problem was affirmed by Corotis and Scanlon who found

> when interviewed, students are quick to point out that there are more lucrative opportunities in other niches of the job market, notably other branches of engineering, and, of course, business. The situation even has the prospect of becoming a self fulfilling prophecy; starting civil engineers are underpaid; a lower echelon of talent is attracted into the profession. The result is that status and challenges are reduced concomitantly.[29]

The salary issue is a difficult one. Salaries for civil engineers in public agencies are often set by averages of the recent past. "They are based on an established scale and all applicants (regardless of differences in quality) are offered the same salary."[30] The result has had a tendency to serve as a dampening force on all civil engineering beginning salaries. As Alexander has pointed out, unlike professions such as medicine and teaching, whose salaries have increased by as

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26 Lipinski, M.. (1992). Undergraduate transportation education: issues, myths, & facts. *TEC Newsletter (Institute of Transportation Engineers), 1(1)*, p. 4.

27 See Mason, Tarris, Zaki, and Bronzini, p. 5.

28 See Corotis and Scanlan, p. 119.

29 *Ibid.*, p. 118.

30 See ITE Technical Council Committee 2-32. (1990), p. 46.

much as 64% since 1955, salaries for civil engineers have actually decreased in constant dollars since 1980.[31]

Introductory Proposal to Strengthen the Agency and University Connection.

This study hypothesizes that, in addition to internal professional development opportunities for DOT employees, the agency and the university must begin working more closely together to expose the new generation of civil engineers more thoroughly to what the profession has to offer. Currently, for example, only about 8% of civil engineering students are provided with opportunities for co-op experiences or internships.[32] Increasing such opportunities would not only enhance the visibility of the DOT but also result in increasing student interest and awareness of what civil engineering is as well as what DOT employment opportunities are available.

Through the use of internal employee improvement and professional development opportunities, including job rotation, managerial training, and continuing education to prepare currently employed engineers for more senior positions, the Iowa DOT should be expected to reduce the projected turnover in professional ranks.[33] Moreover, these opportunities help to create a more qualified, viable, and dynamic employment pool, making it less necessary to recruit from beyond the borders of the state of Iowa. This projection is based on the assumption that universities such as ISU will continue to attract and retain a diverse student population interested in pursuing careers in the public sector.

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31 In Alexander, p. 12. Information taken from *Handbook of Labor Statistics.* (1989). U.S. Bureau of Statistics, Washington, D.C.; Dyckman, Z. (1965). *Study of physicians' income.* U.S. Department of Health, Education, and Welfare; Office of Research and Statistics, p.10; *Statistical Abstracts of U.S.* (1958). U.S. Department of Commerce, Washington, D.C.; *Statistical Abstracts of U.S.* (1959), U.S. Department of Commerce, Washington, D.C.; *Statistical Abstracts of U.S.* (1989), U.S. Department of Commerce, Washington, D.C.; *Handbook of labor statistics.* (1989). U.S. Bureau of Labor Statistics. Washington, D.C.; *Professional income of engineers.* (1956). Engineering Manpower Commission, 25.

32 Discussion with Dr. Edward Kannel, Professor in the Department of Civil and Construction Engineering.

33 Hoel et al. (1990), p. 54.

Chapter II

Producing More Minority Engineers: Retention Insights and Hypotheses

Retention

A General Introduction.

Minority students face obstacles at each level during their tenure within the nation's educational system. Many of these obstacles serve as inhibitors to their recruitment into university engineering programs, while others detract from university efforts at retaining them. Lenning, Beal, and Sauer suggest that retention and attrition result from interactions (or the lack thereof) that take place between students and their institutions.[1] Those interactions are defined in terms of "fit" for the students who remain and "lack of fit" for those who drop out.[2] The university should thus not only acknowledge the differences among students of different sexes and races but also base its attrition efforts on "the specific needs, abilities, interests, and problems of the different groups within its student population."[3] Clewell and Ficklen argue that

> if colleges and universities are to design and implement effective intervention strategies that appropriately reflect the situational circumstances, they must be objectively assessed using data derived from two critical sources--the institution <u>and</u> its students.[4]

The Academic Challenge

Academic Preparedness

Anecdotal data indicate that in most schools the mean grade point average of minority engineering students is well below that of their Caucasian counterparts.[5] These data may explain, in part, why some studies have yielded evidence that even when minority students are provided with curriculum assistance and counseling, their attrition rate remains high.[6] This indicates also

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1 Lenning, O., Beal, P. and Sauer, K. *Retention and attrition: evidence for action and research.* Boulder, CO: National Center for Higher Education Management Systems, p. 27.

2 *Ibid.*

3 McConnell Castle, E. (October 1993). Minority student attrition research: higher education's challenge for human resource development. *Educational Researcher,* pp. 24-30.

4 Clewell, B. and Ficklen, M. *Improving Minority Retention in Higher Education: A Search for Effective Institutional Practices.* Princeton, N.J: Educational Testing Service.

5 See Landis, p. 756.

6 *Ibid.*

that the barriers confronting minority students extend beyond academic assistance and counseling. According to Wilson, data on minority student retention are discouraging to say the least. He reminds educators that

> while on an average 72% of African Americans graduate from high school, only 29% enter college, and only 12% actually finish. At the same time, 83% of Caucasians graduate from high school, 38% enter college, and 29% graduate.[7]

Wilson argues that these numbers reflect a catastrophe and that colleges and universities must begin to seriously address the consequences of this continuing trend. To further complicate the situation, African Americans have been earning only about 3% of university engineering degrees. These numbers are even lower for Hispanic Americans (2.5%).

Researchers suggest there are innumerable reasons for the continued low numbers of racial minorities in the engineering sector, including the following:

- Many minority students come from families that cannot effectively support academic achievement because education beyond high school is not part of the parent's experience.[8]
- Race and gender bias in standardized testing instruments remains a problem.[9]
- Many minorities have inherent deficiencies in their elementary and secondary education experiences.[10]
- Minorities experience a lack of support and/or encouragement from high school and college academic counselors/advisors.[11]
- Minorities are less likely to have adequate financial assistance to attend college.[12]

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7 Wilson, D., Opinion. (February 1, 1988). Black faculty: A key to black student retention. *Black Issues in Higher Education,* p. 1.

8 Gordon, E. (July 1988). Educating more minority engineers. *Technology Review*, pp. 69-73.

9 Zimmer Daniels, J. (May 1988). A program administrator's perspective. *Engineering Education*, pp. 766-768.

10 Forbes, L. and Edosomwan, J. (September 1990). The role of women, minorities, and the handicapped in the engineering sector. *Industrial Engineering,* p.49.

11 Adams, H. (May 1988). Advanced degrees for minority students in engineering. *Engineering Education,*pp. 775-777; Russel, J. (1991). The challenge: recruiting students to civil engineering. *Journal of Professional Issues in Engineering Education, 117(1)*, pp. 21-26; and Tobin, A. and Woodring, R. (May 1988). Prime: A model pre-college minority program. *Engineering Education*, pp. 747-749.

12 See Adams; Forbes and Edosomwan; and Russel.

Generally, low levels of minority representation in engineering are also a result of (1) a lack of role models among faculty,[13] (2) inadequate college counseling,[14] (3) a poor self image, and (4) low self confidence.[15]

While each of the factors presented bears careful and in-depth evaluation, the scope of this study did not and could not emphasize all of them. The following discussion will focus on issues related to the preparedness of students to pursue degrees in engineering, the lack of role models, and the low levels of minority student interactions with faculty and peers as factors contributing to high attrition rates.

Pre-College Engineering Programs

Gordon concluded that minority children often study in secondary schools that are unprepared to provide courses in mathematics and science that are needed for them to succeed in a college engineering curriculum.[16] Out of this finding comes the hypothesis that minority students would be less likely to have been enrolled in a pre-college engineering program in high school than their Caucasian counterparts and that this lack of high school background would make them somewhat less confident of their ability to meet the academic demands of their core courses than their Caucasian counterparts[17]

The Difficulty of Engineering Course Work

Current research suggests that minority engineering students more often than their Caucasian counterparts find that materials presented in their engineering course work are "over their heads" academically and that this has a negative effect on efforts at retention. The researchers argue that this difficulty evolves out of a complex and tightly woven web of social factors. As Asbrand notes, minority students often suffer the effects of poverty, poor public education, an atmosphere of lower expectations that pervades many inner city schools, and racial and ethnic biases.[18] Landis, however, argues to the contrary that

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13 See Tobin and Woodring., pp. 747-749.

14 See Adams; Tobin and Woodring.

15 See Adams; Tobin and Woodring.

16 See Gordon, p.70.

17 These courses include Engineering, Physics, Math, and Chemistry requirements which, at the time of this study, were required by all engineering majors regardless of discipline.

18 See Asbrand.

> better prepared minority students may do worse than less prepared students is a serious indictment of our post-secondary educational system; it should dispel the "myth of preparation" and lead us to examine the educational environment that our predominantly white engineering schools present to minority students. We have a much better chance of getting our own house in order than of revamping K-12 education.[19]

In spite of Landis' findings, our research hypothesized that minority students would share a perception of the level of academic difficulty of courses with Caucasian women. We further hypothesized that Caucasian males, even those who left engineering to pursue other majors, would not identify academic difficulty as their reason for leaving engineering. The expected distinction between women and minorities was that while minorities may well enter the university less prepared academically for the demands and rigors of the engineering curriculum, women engineering students might be expected to "be undone" by their own unreasonably high self expectations.

Barriers to Success: Interactions with Faculty and Peers

Research has shown that interactions between faculty and students are essential to the successful retention of minority students, particularly at predominately white colleges and universities.[20] We also hypothesized that the low numbers of minority faculty within the College of Engineering at ISU, particularly African American and Hispanic American faculty, would have an adverse effect on minority student perceptions of advising as a College retention tool and on their levels of satisfaction with the College and departmental academic advising system and with faculty interactions, including the degree to which students felt they could approach their professors in and out of the classroom for assistance. In a separate study, Hayden and Holloway also found that those minority students who did not continue in engineering felt professors did not take an interest in them and were generally unsupportive. Particularly for Hispanics, their conclusion was that professors were unapproachable and provided no support.[21]

Those who support efforts to draw minorities into the engineering sector express concern that minority students need, but are not receiving, the psychological anchor found in professors

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19 Landis, R. (May 1988). The case for minority engineering programs. *Engineering Education*, p. 756.

20 Green, M. (1976). *Minorities on campus: A handbook for enhancing diversity*. American Council on Education, Washington, D.C.; Noel, L. (1976). College student retention -- a campus-wide responsibility. *Journal of National Association of College Admissions Counselors, 21*, pp. 33-36.

21 Hayden, D. and Holloway, E. (April 1985). A longitudinal study of attrition among engineering students. *Engineering Education*, p. 664-668.

who can act as their mentors. In one study it was found that "four of nine white students felt that faculty members had inspired them to excel academically, while only one in nine minority students reported such experiences."[22] This interaction may be especially important in the classroom setting where both women and minorities often say they find a less than receptive environment.[23] In fact Landis notes that

> minority students frequently report that, instead of encouraging them, faculty send them messages that they do not expect them to succeed. This barrier thus results from a lack of sensitivity that non-minority faculty members tend to exhibit--both to the needs of minority students and to how their behavior affects those students.[24]

In a large university, such as ISU, students' mentors may not only be faculty in the classroom but also other students. Yet current research points out that minority students are less likely to interact with these persons than their nonminority counterparts do. When minority students experience this sense of social and academic isolation, the College will be less likely to retain them.[25] Glennen and Baxley argue that effective advising is crucial, especially in pre-engineering programs.[26]

Peer Group Interactions

Other expectations include the presence of and opportunity to interact with an identifiable racial peer group that would contribute positively to retention of minority students. Research on freshman enrollment and graduation data nationwide have shown that

> minority students are to a great extent ethnically isolated in their classes. If only 8% of engineering freshmen are minority, then a freshman class of, say 25 students averages only two minority students. Worse, if only 4% of seniors are minority, a senior class of 20 averages less than one minority student.[27]

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22 See Landis, p. 757.

23 See Asbrand.

24 See Landis at 757. See also Ivey and Asbrand (p. 261) who reported: An engineering student related the following: "My professor would not look at me even when mine was the only hand raised." "I was very proud," he recalled, "and I insisted on doing what I knew was right." This student consistently received high marks on weekly homework assignments, yet earned a D for the course. When told by the Dean of Engineering that any grade change would have to be made by the professor, the student said "I swallowed my pride and went into his office and asked him to explain how he derived my grade and that I believed the grade I had been assigned was wrong. The professor informed me that to change the grade I would have to retake the course. I did so the following summer and earned an A."

25 See Asbrand.

26 Glennen, R. and Baxley, D. (1985). Reduction of attrition through intrusive advising. *NASPA Journal, 22*, pp. 10-14.

27 See Landis, p.757.

Because peer group interactions can significantly influence a student's academic performance, the cultural isolation that emerges when minority students are in a predominantly white university (1) lead them to miss out on the benefits of sharing information and group study with their peers and (2) increases the likelihood they will incur the negative peer influences of friends who are not pursuing demanding academic work.[28] These findings have been borne out in research that has shown minority students tend to interact less often with their peers. Particularly noticeable is their lack of involvement in student organizations.[29] As Landis further notes

> students typically join student organizations because they are encouraged to do so by others. If minority students have less interaction with students and faculty, they will be less likely to be actively involved in student organizations having predominantly nonminority membership.[30]

Landis says student involvement is the key to success in engineering and that these isolation factors are integrally related to the level of energy that minority students devote to studying.[31] As such, this may have an effect on their ability to develop the time management skills needed to meet the rigors and demands of the engineering curriculum. Lack of good time management skills may then work to the detriment of (1) self discipline, (2) a positive attitude toward engineering studies, (3) motivation to work in study groups, or even (4) to seek tutoring assistance when needed. As Astin writes,

> the highly involved student devotes considerable energy to studying, spends a lot of time on campus, participates actively in student organizations and interacts frequently with faculty members and other students. Conversely, an uninvolved student may neglect studies, spend little time on campus, abstain from extracurricular activities, and have little contact with faculty members or other students.[32]

To counter the isolation factors, Wilson suggests that universities must begin to critically evaluate both the quality and the quantity of the interactions and mentoring of minority students. A study conducted by Rand concurs, pointing out that

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28 *Ibid.*, p.757.
29 *Ibid.*, p.758.
30 *Ibid.*
31 *Ibid.*, p.758.
32 *Ibid.*, p.757.

> There is a pressing need for additional programs, designed in response to the particular circumstances of individual institutions, to support minority students once they begin their studies in college.[33]

The findings of the Rand study do not, however, support the assumption that SAT/ACT test scores are a factor restricting minority enrollments. Even Wilson agrees, noting that "during the past 12 years, the difference in scores between whites and blacks has narrowed substantially even though it remains significant."[34]

Conclusions

The perceptions as well as the experiences minority students share directly influence their persistence in their engineering programs.[35] The quality of the learning environment and the level of student involvement are factors which promote high levels of student interaction which is an underlying factor critical for retention according to the literature. The issues of focus in the Results and Discussion Chapter of this report will be

- the primary academic obstacles confronting minority students at ISU
- the environment the Engineering College at ISU presents to minority students

whether that environment creates barriers that stand in the way of increased minority student interactions with faculty, advisors, and peers -- barriers that Caucasian students do not face.

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33 Devarics, C. (December 1990). Rand study: Black enrollment stagnation in higher education primarily due to high attrition rates. *Black Issues in Higher Education*, p. 4.

34 *Ibid.*

35 Attinasi, L.C. (1989). Getting in: Mexican American's perceptions of university attendance an the implications for freshman persistence. *Journal of Higher Education, 60(3)*, pp. 247-277; Blackwell, J. (1981). *Mainstreaming Outsiders: The Productions of Black Professionals.* New York: General Hall.

Chapter III

Producing More Women Engineers: Retention Insights and Hypotheses

Retention

A General Introduction

Women entering the university in the 1990s have been raised in a social and academic environment that has prepared them to believe they have every opportunity to succeed in careers that have traditionally been held by men.[1] In spite of successful anecdotal data depicting successful women engineers, however, universities including Iowa State continue their search for strategies to recruit and more particularly to retain women students. This effort is especially important for the civil engineering curriculum because it is these graduates who will be the most likely candidates for positions at the Iowa DOT. Some of the obstacles to full participation by women in the engineering sector include:

- the rigors of the required curriculum
- confusion and ambiguity over exactly what engineering entails
- the mechanics of working and competing one-on-one with predominantly male colleagues
- the perception or existence of sexual discrimination in a male-dominated curriculum
- the perceived pressures of meeting the responsibilities of family and personal commitments after entering a technical career
- the identification of available career choices for engineers
- the long-term prospects of professional growth in a selected field[2]

While some of these concerns are expressed by men, women, and minorities, Bakos suggests women have faced more difficulties in pursuing careers in engineering. These difficulties may be a reason why women's participation in the engineering sector has evolved so slowly over the past forty years. As Forbes and Edosamwan point out,

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1 Bakos Jr., J. (1992). Women in civil engineering -- Graduate's perspective, *Journal of Professional Issues in Engineering Education and Practice, 118(1)*, p. 16.

2 *Ibid.*

In 1950 there were 123,601 male and 1,967 female civil engineers nationwide. By 1960, the number of male engineers had soared to 157,117 but women engineers dropped to 918--a decrease from 1.6% to 0.6%. [3]

By 1973 women represented 3% of engineers nationwide. By 1990, however, a report released by the National Science Foundation showed that between 1978 and 1988, the number of women in science and engineering had increased by 258%, while those numbers for men had jumped by 87%.[4] While more than 50% of the current labor force is comprised of women, their participation in the engineering sector has increased to only 15% in spite of the increase in their numbers[5] (See Table 1 for an evolutionary breakdown of trends).

Table 1. National Trends in Engineering Enrollment. Source: Engineering Manpower Commission.

Year	Total Enrollment	Women Enrolled	% of Women
'72	194,727	2,287	2.3%
'73	186,705	6,064	3.2%
'74	201,099	9,828	4.9%
'75	231,379	15,852	6.9%
'76	257,835	21,936	8.5%
'77	289,248	28,773	9.9%
'78	311,237	34,518	11.1%
'79	340,488	42,047	12.3%
'80	365,117	48,944	13.4%
'81	387,557	56,049	14.5%
'82	403,390	62,328	15.5%
'83	406,144	64,649	15.9%
'84	394,635	62,659	15.9%
'85	384,191	61,602	16%
'86	369,520	57,612	15.6%

3 See Fulco and Dallaire, p. 54.

4 National Science Foundation. (March 1990). Women and minorities still under-represented in science and engineering. *Journal of Metals*, p. 5.

5 See Forbes and Edosomwan.

Approaching Changes

A 1991 survey by the *Woman Engineer* showed that 67% of women who are practicing engineers said they had experienced discrimination in college or the work arena, while only 33% of women who were enrolled in engineering programs in universities indicated this level of discrimination.[6] Such a reversal of findings demonstrates the changes that are taking place in colleges and universities as increasing numbers of women declare engineering as a major course of study. These numbers should be encouraging for universities and state transportation agencies that are committed to increasing the participation rate of women engineers in the work force.

Barriers to Full Participation

The Distinctly Male Image of Civil Engineering

Whether Iowa, or the nation for that matter, will tap into the scope of resources presented by the increased participation of women engineers remains to be seen. Many women are discouraged from entering the engineering sector because they are receiving a message that it is not ladylike to be an engineer.[7] Meade argues, "there is nothing like that attitude to keep a smart young woman in her place."[8] Twenty years ago, critics of the distinctly male-image philosophy said, "No one ever told women that most engineering jobs are no more unladylike than jobs in chemistry."[9]

Today, women continue to say that even when they have the high grades, they are not encouraged to pursue this career track because it is for men.[10] Eighty percent of women interviewed in one study said the primary reason for the relatively low number of women entering civil engineering is the failure of counselors to encourage talented young girls to pursue engineering careers. An NSF Young Scholars program designed to attract young women, for example, found little interest on the part of high school counselors. Researchers found even when they made personal telephone calls, counselors were reluctant to participate in this research. In fact, the NSF study, as noted in Chapter I of this report, showed that some of those whose duty it is to advise students on career opportunities are perpetuating the myth that women at least should train for 'appropriate' careers such as secretarial jobs and nursing."[11]

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6 Times have changed. (1991). *Woman Engineer, 11(3)*, p. 8.
7 See Meade, p. 20.
8 *Ibid.*
9 See Fulco and Dallaire, p.55.
10 See Meade, p.20.

Women's Self Expectations: The Confidence Factor

Women's unrealistically high expectations of themselves tend to create a lack of confidence that is not justified. A woman interviewed in one study commented:

> Every woman I've met has got a lack of confidence and I don't know why that is. Technically they're exactly the same (as men), but the amount of confidence a woman has in tackling a project versus the amount a man has--it's phenomenal how different it is.[12]

Another woman commented:

> I think women work very hard, and they have good academic backgrounds. But they lack assertiveness. We get more easily intimidated by men . . . . by some of their behavior . . . I think intimidation is a big problem. Men are more assertive, more sure of themselves, even if sometimes they have absolutely no grounds. And that pays off.[13]

Another study of engineering women at the University of Washington showed that those who drop out of their engineering programs have an "average grade point of 3.2."[14] One student who responded in the study of ISU students seems to echo reasons presented in other research for the high attrition rate of women engineering students. She commented that receiving a grade of B in an engineering course was "just not acceptable." Jane Daniels, Director of the Women in Engineering Program at Purdue University, concludes this may change in time and engineering may achieve parity only after women "feel permitted, in effect, to be as average as the next guy."[15] She comments further as follows:

> All the students who come to Purdue come in with high grades. And all of them, once they get here, wind up getting a lot of Cs, because it's hard. The men say, "That's okay, I'm going to be an engineer anyway." But the women see themselves as complete failures.[16]

For the current study, one hypothesis was that women would contemplate leaving their engineering majors because they have the perception of unacceptably low grades, even when objectively those grades are competitive with those earned by their Caucasian male counterparts. An additional hypothesis was that women are also more likely than men to blame themselves

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11 *Ibid.*

12 See Robinson and McIlwee, p.464.

13 *Ibid.*, p.465.

14 See Meade, p.20.

15 *Ibid.*, p.20-21.

16 *Ibid.*, p.21.

when they do not perform in the classroom at a level they find satisfactory. This relationship was important to test because another one of the prevailing assumptions is that women and men leave engineering for the same reasons--low grades. Research suggests they may not.

The Isolation Factor

Numerous studies of the retention of engineering students indicate that students' perceptions of isolation may have a significant influence on retention.[17] It could even be that a lack of understanding of what engineering education is all about will influence perceptions of isolation, that is, how students talk with peers regarding career aspirations when the student is unsure of what the major is all about.

On the other hand, in a survey of university engineering women conducted by the *Woman Engineer*, researchers found

> few women felt any regular feelings of isolationism, detachment, or loneliness. Several women in their classes actually said being the only woman got them more visibility. The only feelings of isolation resulted from the separate interests or obligations associated with the different sexes.[18]

While student isolation is an elusive concept that may be difficult to define, researchers in the current study hypothesized that the following factors would each play a role in determining the level of isolation affecting women's abilities to (1) identify study or peer groups to work with, (2) receive active support from their mothers, fathers, counselors, and advisors, and (3) use these

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17 Augustine, R. (1966). *Persistence and attrition of engineering students: A study of freshman and sophomore engineering students at three Midwestern universities.* Michigan State University, East Lansing, MI; Ott, M. (1978). Retention of men and women engineering students. *Research in Higher Education, 3,* pp. 755-770; Tinto, V. (1975). Dropout from higher education: a theoretical synthesis of recent research. *Review of Educational Research, 458,* pp. 82-125; Young, H., McAnergy, B. and Daly, B. (1981). Persistence and perception: white and black engineering students. *Engineering Education, 72(2),* pp. 177-179.

18 Bakos, p. 18. While this finding is encouraging, Bakos conducted a qualitative study with a sample size of 40 respondents. Results of qualitative research may well be valid and offer useful insights, yet generalizations of their findings may be questioned when the sample is not random, and therefore not representative of the population it seeks to understand. It is clear that a larger sample size might have yielded a broader range of responses. It is not clear whether the students in the sample were freshmen, sophomores, juniors, or seniors, nor does the article indicate the size of the classes or the region of the country where the study was conducted. Therefore, to generalize these findings to Iowa State University might well be questionable. It is acknowledged that an extremely large sample size is not necessary for representativeness. In fact, many major predictions based on very large samples have been drastically wrong, because the samples, while large, were not representative. However, given all other equal factors, a large sample randomly drawn will have less sampling error than a smaller sample. In Sproull, N. (1988). *Handbook of Research Methods: A guide for practitioners and students in the social sciences.* Determining the sampling method and procedures (Chapter 7)., Scarecrow Press, Inc. Metuchen, N.J., p. 119.

factors to assist them in their decision to leave the College of Engineering. The researchers also hypothesized that in a manner similar to that experienced by minority engineering students, women feel a sense of cultural, if not physical isolation, in part because of a lack of role models.[19]

Parental Support

Bakos concluded that for women, their fathers are "overwhelmingly cited as the strong role model or the major encouraging influence in their decisions to major in engineering."[20] Hayden and Holloway agree, noting that "when a family member is in the engineering profession, retention is increased."[21] Women students need to have access to and support from others who have an interest in their participation in their programs and in their successes. They need to know they are more than just tolerated. Positive changes are likely to become the norm as more of the women engineers' co-workers have interacted more intensively with women peers in their engineering programs at the university level. Other important factors included in the Bakos study were college-oriented families, variety of work choices available in engineering, opportunity to apply mathematics, and most particularly attractive salaries, a perceived recruitment obstacle for the public sector.[22]

Faculty Role Models

The issue of faculty role models is difficult. As of 1991, only 3% of engineering faculty nationwide were women. For some women students this creates a classroom climate that is in itself isolating. At some universities women say "male faculty members, all too often defer to men in the classroom and actively discourage women's participation."[23] While researchers for this report hypothesized faculty role models would not be a major factor in the retention of women engineering students, the lack of role models for women would nonetheless be expected to have a negative effect on the women's views of advising as an effective retention tool for the College.

Low numbers of women students and faculty are likely to remain problematic. As Bakos comments, a certain level of discomfort, due in part to a lack of role models, may carry over into the professional realm. In the workforce, for example, women report

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19 In the Department of Civil and Construction Engineering at ISU there are two women faculty. One in structures, one in geo-technical. There are no women faculty in the transportation section within the department.

20 See Bakos, p. 18.

21 See Hayden and Holloway, p. 664.

22 See Bakos, p. 18.

23 See Meade, p. 21.

- being called stereotyped names
- listening to crude jokes in the field
- being treated as an oddity
- always walking into a room full of men
- experiencing a sense that many males are very uncomfortable around female engineers and thus do not speak or act freely or normally
- being treated as if you are a token[24]

Conclusions

More than one-half of the women who are either working as engineers or who are students in engineering programs have a family member who is an engineer.[25] When women enter engineering programs, however, they also need support from their peers and from faculty and advisors. In part because the engineering profession, particularly civil engineering, still bears a distinctly male image, additional efforts must be made to dispel this image in order to avoid losing a talented resource pool. Women need positive role models, including parents, teachers, classmates, and counselors; but few who voice an interest in engineering ever receive such reinforcement.[26] As Baum notes, however,

> The system is not as supportive of women as it could be; nor is it as supportive of men as it could be. Changes in rules for both sexes are necessary as we move into the twenty-first century. [27]

The perceptions as well as the experiences women students share will directly influence their persistence in engineering programs. As it is with minorities, the quality of the learning environment and the level of student involvement are factors which promote high levels of student interaction, an underlying factor critical for retention according to the literature. Because many universities do not enroll sufficient numbers of women in their engineering programs to create a critical mass, these students often lack support systems and effective networking opportunities.[28] Universities like ISU are working on attrition rates with programs such as Women in Science and

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24 See Bakos, p. 20.

25 Baum, E. (December 1990). Recruiting and graduating women: The underrepresented student. *IEEE Communications Magazine*, p. 48.

26 Ivey, E. (May 1988). Recruiting more women into engineering and science. *Engineering Education*, p. 762.

27 See Baum.

28 See Ivey.

Engineering. These programs, however, may not address some of the concerns relayed by women students regarding their interactions with faculty or advisors.

The issues of focus in the Data Analysis Chapter of this report will be

- the primary academic obstacles confronting women engineering students at ISU
- the environment that the Engineering College at ISU presents to women students
- the question of whether that environment creates barriers that stand in the way of increased interactions with faculty, advisors, and peers--barriers that Caucasian male students may not face.

Chapter IV

Methods

Demographics of the College of Engineering: Fall 1993

In the fall semester of 1993 when this study was conducted, there were 3,963 students enrolled in the College of Engineering. The breakdown of these numbers by race and sex is as follows:

- 3,037 Caucasian men (76.6%)
- 603 women (15.2%)
- 323 (8.1%) minorities

The university's records on minorities include those who are

- United States citizens
- immigrants (defined as holding a "green card")
- refugees, some of whom were in the United States as political refugees.

For purposes of this study, only African Americans, Hispanic Americans, and Native Americans were included because at that time these were the only groups considered by the university as protected classes. Of those students classified as minorities[1] there were

- 126 African Americans
- 56 Hispanic Americans
- 7 Native Americans

The increase in the number of minorities reflects a trend that might be construed as leading to an increase of minorities in the engineering sector. As it was pointed out in Chapter 3, however, the number of engineering students who graduate from accredited programs in engineering has

[1] There were also 134 Asian Americans. None of these students, however, was included in this study.

remained constant at approximately 3% (2.5% for Hispanic Americans) over the past 20 years. The dropout rate for these students, however, even at Iowa State University, remains unacceptably high.

The numbers of women enrolled in the Engineering College is consistent with their numbers nationwide, as is their attrition rate which remains at about 50% prior to graduation. A majority of these Iowa State students are lost from the College prior to actually declaring a particular engineering major.[2]

The focus of this chapter will be on presenting (1) the source of the data, (2) the method of data collection used in this phase of the research, and (3) those factors that can be used as indicators of retention and conversely, attrition.

Source of the Data

Women and Minorities

The primary objective of this study was to identify problem areas resulting in an unacceptably high attrition rate for women, minorities, and to a lesser degree, Caucasian males in the College of Engineering,[3] particularly in the Department of Civil and Construction Engineering (CCE) at ISU.[4] These are the students who are the most probable candidates for future Iowa DOT engineering positions. Because the number of women and minority students enrolled in CCE was too small for a valid data analysis, the decision was made that all women and all protected minority, undergraduate students across the College of Engineering would be included in the study.

Caucasian Men

A random sample of Caucasian male students from across the College was also selected for participation in this study. They were included because it would be difficult or even impossible to draw conclusions regarding retention of engineering students by examining only underrepresented groups. That is, the College also loses a significant portion of Caucasian male

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2 A student is classified as pre-engineering until a required number of classes has been taken and the student remains in good standing with at least a 2.0 grade point average.

3 Hereafter when the term "College" is used, it shall refer to the College of Engineering unless otherwise designated.

4 Researchers on this project worked closely with the College of Engineering and with the Registrars Office to gain access to the names, addresses, and other relevant information regarding the population and sample of engineering students who would be chosen for participation in this study.

students prior to graduation.[5] It is likely that many Caucasian males face some of the same obstacles that women and minorities face. As such, these obstacles become general institutional issues and not just specific institutional or environmental issues confronting underrepresented groups. It is, therefore, also likely that Caucasian men drop out of their engineering majors for at least some of the same reasons their women and minority peers do. To ignore this as a probability would have seriously jeopardized the validity of this research.

Persisters and Nonpersisters[6]

Those selected to receive a copy of the questionnaire entered ISU between Fall Semester of 1988 and Fall Semester of 1993. All of these students (for a total of 3,100) were either currently enrolled in an engineering curriculum or they had entered the university as (pre)engineering majors but had since changed their majors and were currently enrolled in other colleges and departments within ISU. It was beyond the scope and the budget of this research to track students who had dropped out of engineering and left the university.

Rationale for Including Both Persisters and Nonpersisters

Both persisters and nonpersisters were included because the researchers believed it to be important to understand obstacles confronting students[7] currently enrolled in the College. In addition, the researchers felt it important to gain additional insights from those students who had not been retained in engineering, but who had decided to remain at ISU in other departments, primarily outside the College of Engineering (Figs. 1 - 4). The reasons why these students left engineering would provide the College with information that had not been previously available. The researchers projected, however, that the response rate for nonpersisters would be low and assumed that students who had already dropped out of engineering might not recognize the importance of their feedback for future cohorts. This was borne out as only 167 of 1200 (13.9%) nonpersisters returned completed copies of the questionnaire. Of those, 152 were Caucasian (46 women and 106 men) and 15 were minorities. The sample size of minority nonpersisters was not large enough to permit an empirical analysis.[8] Frequency distributions were used, however, to provide some insights into their responses.

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5 The rate hovers at 50% for both women and men.

6 Those students who are currently enrolled in engineering majors will be referred to as persisters, while those who have become part of an attrition group will be referred to as nonpersisters. Both groups were included in this study.

7 Whenever the term "students" is used it refers to men, women, and minority students.

Generalizing the Results

Two of the most important objectives of a research design are identifying the appropriate target population and selecting a random sample of students. If these objectives cannot be attained, the extent to which researchers can draw conclusions about the entire population becomes questionable.[9] For this study it was critical to have a sample size large enough to permit a valid data analysis. It was also realized that a significant number of engineering students drop out of their majors prior to completing their sophomore year at the university. At the time this study was carried out, all students were required to enroll in a number of core courses to prepare them for upper division engineering course work in their respective majors. These courses included Engineering 160 and 170[10], Physics 221 and 222[11] and Math 165, 166, 265[12], and Math 266 or 267.[13] It is this course work shared in common that influences many students to either continue in their engineering majors or to consider changing their majors. Because of their collective exposure to these common core courses, the researchers assumed that for this study it would be valid to draw respondents from across the College.

Overall Response Rate

Questionnaires were mailed to 149 minority students, 629 female students, and a random sample of 1,200 Caucasian male students currently enrolled in the College (persisters). Questionnaires were also mailed to a random sample of 1200 nonpersisters. For both Caucasian male persisters and all nonpersisters, the College performed a computer search to identify a random sample so that each person in each category had an equal chance of being selected for participation in this research. In this way, there were no departments, classifications, sexes, or races more likely than others to be chosen to receive the questionnaire.

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8 N = 7.

9 Vogt, W. *Dictionary of Statistics and Methodology: A Nontechnical Guide for the Social Sciences.* Sage Publications: New York, p. 98.

10 At the time of this study all engineering students were required to enroll in Engineering 160 which is a Computer Programming course and involves both Fortran and Engineering Problem Solving). They were also required to take Engineering 170, which is a course in Engineering Graphics. As of the fall of 1995, required enrollment in Engineering 170 will be curriculum dependent and Engineering 160 will expand beyond Fortran Programming to include C-Programming.

11 All engineering students have also been required to enroll in Physics 221, which is Principles of Mechanics, and Physics 222, Electronics, Magnetism, and Wave Theory.

12 All engineering students are required to enroll in Math 165, 166, and 265, which are calculus courses.

13 Each of these courses offers a different form of differential equations.

The final sample size, including both persisters and nonpersisters was 831. Table 2 depicts a breakdown by year in school for all persisters (N = 664) who completed and returned the questionnaire.

Table 2. Breakdown by year in school for persisters who completed and returned a copy of the questionnaire.

Year in School	Frequency	Percent
Freshmen	160	24.1
Sophomore	127	19.1
Junior	112	16
Senior	265	39.9
Total	664	100

Table 3 depicts a breakdown by year in school for all nonpersisters (N = 167) who completed and returned the questionnaire.

Table 3. Breakdown by year in school for nonpersisters who completed and returned a copy of the questionnaire.

Year in School	Frequency	Percent
Freshmen	23	13.8
Sophomore	38	22.8
Junior	55	32.9
Senior	51	30.5
Total	167	100

Of the total number of respondents, including both persisters and nonpersisters, 31.1% were women, 7.2% were minorities, and 64.1% were Caucasian men. Minority women comprised 2.5% of the total sample.

The breakdown by year in school for the 95 persisters within CCE who completed and returned the questionnaire is as follows: 34 (37.7%) were women, 56 (58.9%) were Caucasian men and 7 (7.3%) were minorities. During the Fall Semester of 1993, 13 pre-civil engineering[14] students enrolled in CCE and 2 who had declared the civil engineering curriculum and none from the construction engineering curriculum. Fall Semester of 1994, there were 10 minority students who were pre-civil engineering curriculum and 1 who had declared the construction engineering

[14] Students must complete a specified number of engineering courses, before they are permitted to declare civil engineering as their major course of study. Prior to this time, they are declared as pre-civil engineering.

curriculum. During the Fall Semester of 1994, there was still 1 minority student who had declared the construction engineering curriculum and 3 who had declared the civil engineering curriculum, presented for a loss of 4 students (26.6%) over the course of the year

Minority students (in general) were not classified by distinct race for purposes of this analysis because their numbers overall were too low for data analysis purposes.

The Questionnaire

In the process of designing the questionnaire, researchers worked closely with the Iowa DOT expert advisory group members, including three women engineers, two minority engineers (including one African American and one Indian), and three Caucasian male engineers.[15] Members of the expert advisory committee from the College of Engineering, included an Assistant to the Dean and the Coordinator of the Women in Engineering Program. Finally, two faculty from the Department of Psychology worked closely with the researchers in designing the questionnaire.[16]

Input from these diverse sources allowed an emphasis not only on the substance of questions asked but also on the validity of the items included in the final draft. The final copy of the questionnaire was approved by the University Human Subjects Review Committee, the College of Engineering, and the Technical Monitor from the Iowa DOT prior to being mailed.

Two versions of the questionnaire were developed. One version was designed to be sent to persisters and the other version to nonpersisters. These questionnaires were identical in content. The distinction between them involved only the wording of the questions. For persisters, questions were worded in present tense and for nonpersisters, they were worded in past tense to reflect the reasons these students had left the College. Copies of each version of the questionnaire are included in Appendix B of this report.

The Dean of the College of Engineering agreed to write the cover letter for the survey with the hope this act might encourage students to recognize the importance of this study from the administration's point of reference. A copy of this letter is also included in Appendix A.

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[15] Researchers want to especially acknowledge the assistance from Jim Grove from the Materials Lab at the Iowa DOT for the time he took on very short notice to provide input into the final draft of the questionnaire.

[16] The researchers gratefully acknowledge the assistance of Dr. Doug Epperson and Dr. Anita Kelly from the Department of Psychology for their valuable assistance in assisting with both the design of the questionnaire and refining it.

Additional Types of Data Collected and Analyzed for this Study

Grade Point Average

Researchers received permission from Iowa State University's Human Subjects Review Committee to gain access to respondents' Social Security numbers. Because of the sensitive nature of these data, researchers were required to assure students of complete confidentiality and anonymity. Students who received a copy of the questionnaire were also informed that once their responses were entered into the computer, their social security numbers would be deleted to prevent any chance of compromise. Students were asked to sign their names indicating they had given researchers their permission to access this information which would include both grade point average and SAT/ACT scores. The form students were asked to sign to release this information is included in Appendix B attached to the questionnaires.

Student grade point averages are one of the key predictors of retention in engineering programs. As such it was critical for the researchers to gain access to this information (See discussion of grade point averages in chapters on both women and minorities).

Questionnaire Items Reflecting Student Isolation. As discussed earlier in this report, academic satisfaction factors, isolation factors, and academic preparedness factors are often keys to predicting which students will be retained in the College and which will drop out prior to graduation. Each of the following items is marked as "AS" for academic satisfaction, "I" for isolation, and "AP" for academic preparedness items. These items included the following:

- As an engineering student at Iowa State University, are you actively involved in any Engineering Societies or Organizations? (I, AS)
  1. Yes
  2. No

- Do you know about and/or have you used any of the following services as an engineering major at Iowa State University? (I, AS, AP)
  1. Student Counseling Services
  2. Departmental Help Centers
  3. Tutoring Services
  4. Tau Bet Pi (Free tutoring)
  5. Women in Science and Engineering

- From which of the following sources did you receive active <u>encouragement</u> to study engineering when in high school and/or college? (I)
  1. Parents, siblings, or other relatives
  2. Pre-College Programs through high school, including high school counselors
  3. Summer enrichment programs

- I usually find no difficulty identifying friends/peers to study with. (I, AS)
- Academic advising is satisfactory in engineering (I, AS)
- How confident are/were you that you can/could meet the demands of your math, chemistry, physics, and engineering courses. (I, AP)
- Peer group support (I)
- Support of faculty in and outside the classroom (I, AS)
- The importance of study groups (I, AS)
- Support from parents (I)
- Availability of mentors and role models in engineering (I, AS)
- Effectiveness of the advising system as a retention tools (I, AS)
- Effectiveness of student organizations as retention tools (I, AS)
- *Time management skills*
- Self discipline
- Good study habits

Finally, in order to test students' perceptions of the recognition factor, researchers asked

- Whether engineering is really what they thought it would be.

Chapter V

Results and Discussion

Introduction

The objectives of this chapter will be to present the results of the data analysis of phase two of this research and to explain those results. Student responses to the questionnaires were analyzed by using descriptive statistics rather than inferential statistical tests. Percentage scores and means were used to depict responses. Likert scaling was used with a range of 1 to 6 on most items (with 1 representing strong agreement with an item and 6 representing strong disagreement). The results are presented as indications of the current environment at ISU and will be used to present insights on retention from students' points of reference. Recommendations that are offered will be designed to increase retention rates for Caucasian men, women, and minority engineering students and to strengthen the ties between ISU's CCE Department and the Iowa DOT. Only in this way will the Iowa DOT be more assured that it will have a pool of the most highly qualified applicants for positions.

Identifying a Viable Pool of Engineers for Public Sector Engineering Positions

In 1985 a national study conducted by the Transportation Research Board (TRB) concluded

> the stability of the professional work force may in many states **require** an adequate supply of new professionals from **within the same state or region**. If a state's peak demand for new professionals exceeds the capacity of its traditional nearby channels of new entrants, it **may encounter exceptional difficulty recruiting or retaining graduates from other regions.**[1]

Maintaining a viable pool of applicants for vacant DOT engineering positions will become increasingly vital as the nation, including Iowa, approaches an era where

> a new generation will soon be running the public agencies that build and maintain the nation's highways, streets, and transit systems. The professionals who built the Interstate system will soon retire and so will many of the more seasoned managers, executives, and supervisors who helped expand transit service in the 1970s. One-third of the pool of transportation engineers employed in 1984 are expected to retire by 1995.[2]

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1 Transportation Research Board. (1985). *Transportation Professionals: Future Needs and Opportunities, A Study of Transportation Professional Needs for Highway and Mass Transit Agencies in State, Local, and Federal Government (TRB Special Report 207).* National Research Council: Washington D.C. , p. 8 (Emphases added).

2 SeeTransportation Research Board (1985)., p. 80.

Demographics: The Iowa DOT

TRB generated its findings nearly ten years ago. Nonetheless, for Iowa, its predictions remain valid. For example, the Iowa DOT currently employs a total of 237 engineers, including registered professional engineers and engineers in training. Of this total, 96 were between the ages of 46 and 65, as of December 12, 1994.[3] This means that between 1994 and the year 2010 nearly 40% of the total number of engineers currently employed at the Iowa DOT will be phasing into retirement. These predictions may, in fact, be conservative because they do not account for additional losses of engineering employees that may occur due to deaths or other attrition factors. Thus it is more important today than ever for the Iowa DOT and ISU to work together jointly to (1) increase the visibility of the CCE Department and (2) to use that visibility to more effectively sell the excitement and dynamics of public sector civil engineering careers to prospective civil engineers within the State of Iowa.

The Need for Effective Recruitment Strategies

As the decade of the 1990s continues, it will become increasingly important for the Iowa DOT to retain its experienced engineering employees. The loss of 40% of its work force to retirements over a 14-15 year time period will require the remaining professionals to assume an increase in responsibilities at each level of the agency as the organizational hierarchy adjusts to fill the vacancies at or near the top. This is likely to mean that morale will become increasingly important because it is integrally related to employee motivation and productivity. As it was pointed out in Chapter 1 of this report, the agency agrees it must adapt its processes now so that all its employees continue to be recognized as valuable resources that must be carefully managed, developed, challenged, and rewarded."[4]

The Role of Affirmative Action

Federal affirmative action regulations require a periodic analysis of the work force to assess the status of efforts to increase the proportion of women and minorities employed in the public sector. The Iowa DOT, however, appears to be exceeding affirmative action guidelines. It

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3 The total number of engineers employed with the Iowa DOT that were provided to the researchers in phase one of this research was 274. We were just informed that this number included co-op interns who should not have been counted as engineers. Currently, the Iowa DOT employs 237 persons who are either Engineers in Training or registered Professional Engineers and an additional 31 who are co-op interns. Those in this latter category are not considered to be a part of the engineering staff because they serve in this capacity for a semester and then move back into their classrooms to complete their degrees.

4 See Iowa Department of Transportation. (1991), p. 17.

currently employs 20 minority engineers (8.4% of the total number of engineers) and 12 women (5% of the total number of engineers). With this in mind, while the number of African American (N = 1) and Hispanic American engineers (N = 2) remains extremely low, the Iowa DOT has a solid "general" record on hiring minority engineers. It is from these latter two groups that the university might well be able to provide increased numbers of in-state applicants for engineering positions.

If the DOT begins to recruit minorities from beyond its borders, it risks alienating its work force, including engineers and those technicians and secretaries who work most closely with them. For example, in phase one of this research, many DOT employees indicated they were strongly opposed to efforts to actively recruit from beyond the borders of the state. As noted in the interim report, affirmative action guidelines do not mandate that the available pool be defined as a national search for qualified engineers.

Traditionally, searching beyond the state's borders would have helped to ensure that the competition would draw in more highly qualified candidates. If, however, ISU is able to retain increasing numbers of students in all categories, including Caucasian men, women, and minority CCE students, then the available pool of qualified applicants (within all categories) from within the state should increase. This result should, in turn increase the level of competition for positions making it increasingly probable that the most qualified candidate will be or can be hired for the job regardless of race or gender.

The remainder of this Chapter will focus on (1) an analysis of the issues most critical to resolving ISU's retention problem for students enrolled in the civil and/or construction engineering curricula and (2) recommendations designed to produce qualified women, minorities, and Caucasian men who then become available to apply for DOT engineering positions.

The 1992 NCHRP report on civil engineering careers concluded that state transportation agencies must begin to adopt aggressive practices to stimulate interest in civil engineering.[5] The following section of this report will identify why there is a seeming lack of interest in civil engienering. The report proposes that the lack of interset stems from a lack of understanding of what civil engineering is. The discussion on this topic will serve as a prelude to the

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[5] See Transportation Research Board (1985)., p. 10.

recommendations for ISU's CCE Department (to retain) and the Iowa DOT (to attract) students/graduates.

Resolving any problem requires taking the first step, which is acknowledging there is a problem. In agreeing respectively, to endorse and sponsor this research, both ISU's CCE Department and the Iowa DOT have done this. The second step is to address that problem from both the institution's point of reference and the students' points of reference. That second step is the focus of this study and should lead to a third step that will be to identify and then negotiate an action plan for implementing efforts designed at retention that will provide positions for ISU graduates, and thus benefit both the Iowa DOT and ISU.

A Sense of Community

One mechanism for alleviating women and minority students' feelings of isolation may well be to present opportunities for them to begin to identify themselves as members of a pre-professional community of aspiring engineers. To illustrate, Landis reported on a model program initiated in California where

> a formal orientation course for new freshmen is offered which awards academic credit and spans the entire academic year. As the primary focus of the course is to develop a strong sense of group cohesiveness and spirit, class activities are conducted to get the students to know one another, feel part of the group, develop an attitude of mutual support, and know how to help each other.[6]

In addition to informing students as to what engineering is, such a program would serve to promote an academic and peer group support system for students. Landis also suggests clustering minority students in common sections of classes. Such clustering would be challenging for the CCE Department at ISU because there are only seven minority students currently enrolled in the department Efforts to retain those students, however, could serve as a mechanism by which additional minority students could be encouraged to declare CCE as a career path. Such efforts would also serve to alleviate the cultural isolation that in many instances precludes development of a sense of community among students. In the long run these efforts could conceivably draw

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[6] See Landis, R., p. 760.
See also Landis, R. (1988). *Academic gamesmanship: Becoming a 'master' engineering student.* NACME: New York. (Emphases added).

other minority students into the program. It is also suggested such a strategy could be beneficial if applied to the retention of women and Caucasian men engineering students.

The Recognition Factor

General Background Information

In a 1990 article generated by the Institute of Transportation Engineering (ITE), it was pointed out that

> Civil engineering has often been recognized to be the engine that drives society's progress. From the days of the early pyramids, man's achievements and welfare have been measured largely in terms of civil engineering accomplishments. It is reasonable to assume that the 21st century will see a continual demand for civil engineering types of services.[7]

Nonetheless, a recent study conducted by the National Cooperative Highway Research Program concluded

> **The poorly defined image of civil engineering is a serious impediment to recruiting new entrants to the profession.** While it has long been acknowledged that civil engineering has an image problem, the pervasiveness and negative effects of the problem are far worse than many civil and transportation engineers realize. In addition to its deleterious impacts on recruitment, this poor image frustrates many other efforts of the profession such as those related to legislation and public affairs, where the understanding and support of the general public are critical for success.[8]

The conclusions drawn by the NCHRP Report and other research reviewed for this study[9] have led to the hypothesis that many engineering students do not have a clear conception of what the practice of civil engineering entails.

Women Students and the Recognition Factor

General Comments. One of the significant barriers to recruiting women into engineering programs in college is the difference in the amount of career information and encouragement provided to young girls and boys.[10] Clearly, "women account for little more than a trickle in the

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7 See ITE Technical Council Committee 2-32. (1990)., p. 44.

8 Mason, J., Tarris, J. and Zaki, E. (1992). *National Cooperative Highway Research Program Report 347.* The Pennsylvania Transportation Institute, Transportation Research Board, National Research Council: Washington, D.C., p.18.

9 See Hayden and Holloway, p. 664; Meade, pp. 19-22; Greenfield, L., Holloway, E. and Remus, L. (November 1982). Women students in engineering: Are they so different from men? *Journal of College Student Personnel*, pp. 508-514; Bakos, pp 16-29.

10 Casserly, P. (1983). Encouraging young women to persist and achieve in mathematics. *Children Today,12,* pp. 8-12.

engineering pipeline."[11] Women, for example, comprise 34% of medical school students, 31% of all MBA degrees, nearly 40% of students in law schools,[12] yet only 15% of engineering students.[13] One of the reasons for this disparity in percentages is, of course, the male image of engineering,[14] but it cannot be understated that a significant share of young people, including boys, simply do not understand what engineers do. When the visibility problem discussed in the NCHRP report is added to the fact that an estimated 90% of young women who enter engineering do so against the advice of their counselors and teachers, parents, and peers, the encouragement factor becomes increasingly important.

Minority Students and the Recognition Factor

General Comments. Minority students who do not remain in their engineering programs until they have earned their engineering degrees report that "the information about engineering education obtained from primary sources such as acquaintances and parents is not very accurate."[15] They enter engineering without adequate recognition of the skills they will need to practice the profession for which their education will prepare them. Caucasian men are no better informed. If universities, including ISU, hope to retain women and minority students, and indeed Caucasian men, all engineering students must be provided with sufficient information about what their curriculum will prepare them to do in the professional world. Rybak[16] and Hayden and Holloway[17] suggest the following factors are critical if retention rates are going to increase:

- The difficulty of the program should be made clear during the recruitment/application stage, not just at freshman orientation.
- Students should also be informed about the benefits of engineering careers during the recruitment phase. **The reason**: Studies show that students with the most realistic views of the profession are the most likely to succeed.

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11 See Meade, p. 21.

12 *Ibid.*

13 At Iowa State University during the fall semester of 1994, the enrollment of women in the Civil and Construction Engineering Department was higher than this national average, accounting for 20% of the total number of students enrolled.

14 The issue of the male image of civil engineering will be discussed more fully in Chapter 3.

15 See Hayden and Holloway, pp.664-668.

16 Rybak, J.P. (1985). Start students out right and keep them. *Engineering Education, 75(8),* pp. 724-726.

17 See Hayden and Holloway, pp. 664-668.

In one study, information regarding engineering was one of the key factors that separated minority students who persisted and earned their degrees from those who changed majors or dropped out of school altogether.[18] Research shows that maintaining students' interest levels in engineering while they are still declared as pre-engineering students is a factor contributing to retaining minority students a well as women and Caucasian males. This can be accomplished through (1) engineering school site-visits, (2) extracurricular activities with like-minded peers, (3) one-credit classes that orient students to engineering and provide them with problem solving skills, (4) field trips that can be arranged to observe practicing engineers and 5) providing exposure to industry settings. While universities, including ISU offer courses where students work on required group projects, these are generally upper division, senior classes. Rybak suggests first year students, for example, could begin by building a scale model of the university campus to maintain their interest in engineering and to raise their self confidence.[19]

Retention Efforts

If efforts to retain engineering students, in general, are going to be successful increasing the visibility of civil engineering as a chosen course of study must increase at a number of levels. The key is to ensure that students have a clear and concise understanding of what it will mean to be a practicing engineer.

All engineering students enter the university with notions of what they expect from their major departments. Those expectations are "to gain a better understanding of engineering and to establish a good foundation in math and science."[20] In response to the following question, however, it is clear that a number of ISU engineering students clearly suffer from a "curriculum and profession clarity" problem.

How strongly do you agree or disagree with the following items regarding your perception of engineering?

1	2	3	4	5	6
Strongly Agree					Strongly Disagree

Engineering is/was not really what I thought it would be.[21]

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18 See Hayden and Holloway.

19 See Rybak, p. 694.

20 Greenfield, L., Holloway, E., and Remus, L. (November 1982). Women students in Engineering: Are they so different from men? *Journal of College Student Personnel, 23(6)*, p. 511.

21 Persisters were asked whether engineering is what they thought it would be. Nonpersisters were asked whether engineering was not what they thought it would be.

The Recognition Factor and Persisters

Of all persisters in the College, regardless of major, 25.1% somewhat strongly to strongly agreed that engineering was **not** really what they thought it would be. For all CCE majors that number dropped only slightly, to 22.1%. The percent dropped to 19.6% for Caucasian men and 20.5% for women. When the responses of the 11 men and 7 women are added together, 20% of the total number of students in CCE said engineering was not what they thought it would be. When controlling for minority students, the percent indicating they were not sure what engineering is all about increased to 57.1%.

The Recognition Factor and Nonpersisters

When frequency distributions were performed for nonpersisters, the results showed overwhelmingly that students were not clear on what engineering really is. Seventy-three percent (N = 81) of a total of 111 Caucasian men, 80% (N = 36) of a total of 45 women, and 93.3% (B = 14) of a total of 15 minorities either agreed or strongly agreed that engineering was not at all what they thought it would be. The number of minority nonpersisters in this study is too small for statistical analysis (N = 7), but, nonetheless, the finding is consistent with other research that shows the less information entering students have about engineering, the less likely those students are to be retained.[22] Iowa State University, for example, loses more than 50% of its minority engineering students prior to their graduation. This finding suggests that ISU needs to focus on increasing the visibility of engineering, particularly civil engineering. The implication for some students is they are not even sure what questions to ask to clarify what it is they do not understand.

Student Comments on Recognition Item. One student in this study commented

> The university really needs to spread the word to more high schools, including (especially) small schools, about just what engineering involves. While you might get some people who decide it is not what they want, at least they can decide that before they have wasted a year or two or three. Also you might find some people who would otherwise not have considered engineering who might become interested.

Other students suggest that there needs to be more applied classroom components early in their academic experiences. A Caucasian CCE male, for example, said

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22 See Hayden and Holloway, p. 664-668.

> It is hard for me to determine if civil engineering is what I want. Being placed directly into the engineering program is great but I don't even get a taste of civil engineering until my junior year and what if I don't like it? Then my only choice is to pick a different engineering major because I was put directly into the engineering classes.

Another student said

> I have almost completed four years in the engineering program. I plan to graduate in another year and I really don't know that a construction engineer does. I'm worried that I will not like my job once I get done with school. More insight into the real world needs to be implemented into our curriculum so we will have a better understanding of what we are getting into and be less likely to throw away four or five years of schooling.

One student concluded by saying his perception is that an overwhelming majority of people at the high school level (including teachers and counselors) have little to no idea of what an engineer does. This problem is often magnified for minority students who also may **not** know of any family members or friends who are engineers. As a result, the information they receive may be both insufficient and distorted.

Students who said they were still unsure as to whether they want to enter the engineering sector upon graduation also conveyed the message that "we need to know exactly what we would be doing in a job before we can know if that is what we want to do." From the required course work they have taken, many say it is difficult to know if they are in the program that is right for them.

Some civil engineering students at ISU have commented they do not even have an opportunity to see the Town Engineering Building[23] until they reach junior status. From their point of reference, this precludes any opportunity to learn to know who the faculty are or what those faculty are interested in regarding the discipline or the profession. Some also say they wish they could be assigned faculty mentors within the department so they could become more readily acclimated as freshmen or sophomores. A Caucasian male persister noted,

> I would advise assigning students to a specific advisor. Allow walk-in service, but require students to go to a specific advisor for Adds/Drops, degree programs, and curriculum changes. This would allow students to quickly see an advisor, but still keeps a better match on students, i.e., one and only one advisor authoring changes for the student and therefore learning to know the student better as a person.

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[23] Offices for faculty in the Department of Civil and Construction are located in the Town Engineering Building.

While in the Civil Engineering curriculum, freshmen students are assigned a departmental advisor; in the Construction Engineering curriculum, they do not work directly with departmental faculty until they have satisfied course requirements needed to shift from a pre-construction engineering status to declaration of Construction Engineering as the major curriculum. Students argue that advisors play an important role in retention. For example, several students (across the College) said that if they were assigned an advisor as freshmen who would follow them through their entire program of study, they would feel less alienated and more likely to identify with a particular curriculum. One woman nonpersister commented on this issue in her statement below:

> I was not satisfied (overall) with the College of Engineering. I tried for five semesters. I received no personal attention except for my paid tutor. Maybe I just wasn't made to be an engineer--but no one ever tried to keep me in the program.

These might well be considered appropriate comments from students, since the department tends to lose a significant number of pre-civil and pre-construction students prior to the time they would declare CCE as their major department.

These factors may serve as a deterrent to retention for some students, particularly those who already feel isolated, either because of race or gender. Losing these students may not be a function of their levels of academic preparedness and/or ability to succeed in engineering, but rather it may be related to the students' needs to better understand <u>and</u> feel a part of this low visibility department. Additional discussion on advising and student faculty interactions will be presented in a later section of this Chapter.

Current Efforts to Counter the Recognition Factor

The *Committee on Women and Minorities in the CCE Department* make some effort each academic year to draw underrepresented student groups (particularly women) in for informal activities designed to introduce students to the faculty and their upper division peers. Because they were new to campus many of the invitees said they were somewhat intimidated meeting with faculty on this level or that they were too absorbed in the rigors and demands of their course work to take the time for these types of events.

For example, two years ago, the *Committee on Women and Minorities* scheduled a fall event to welcome freshmen women who are pre- CCE students to the department. The

departmental Chair and several senior level women CCE students were invited so the freshmen women could feel free to ask them questions about the CCE program and about civil engineering as a profession.

Letters of invitation were mailed to 21 freshmen women along with a card that listed names of women faculty in the department and women officers of the student organizations, including Chi Epsilon (Departmental Honor Society), the Association of General Contractors (AGC), and the American Society of Civil Engineers (ASCE) Student Chapter. It was believed these persons could serve as mentors or contacts for these students. Five of the 21 students who had been invited attended this event. Of those, three had already considered changing their majors from the civil engineering curriculum to something else. As such the impact of this type of event may be questionable.

One of the women faculty members in CCE also has a barbecue dinner at her home at least once a year inviting all women students enrolled in the department. This type of informal gathering also presents students with opportunities for networking and for developing a sense of community.[24] Feedback from students has been very positive regarding this event.

Additional Recommendations to Counter the Recognition Factor

Some efforts designed at retaining students in CCE could begin at the departmental level and include

- Inviting freshmen students in to visit engineering laboratory classes and upper level Capstone Design classes to familiarize them with the practice of engineering. This would also serve to introduce them to the senior level students who could serve as peer mentors for freshmen and sophomore level students.
- This event could also serve to stimulate their motivation to seek internships and summer employment where they could, albeit at a low level, begin to apply some of their engineering knowledge.

Exposure to applied engineering projects could counter some student perceptions that "the engineering curriculum is too rigid and doesn't allow opportunities to explore."[25] At the same time, however, some students were frustrated with the lack of opportunities for co-op experiences and internship opportunitites. One minority student persister commented, for example,

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24 To the researchers' knowledge no such informal departmental activities have been set up for bringing minority students into the CCE community.

25 Comment made by a Caucasian male.

> I have been trying to expand my knowledge through engineering work experiences and found that if your GPA is less than 3.00 there are no opportunities for you. No co-ops, no internships, no summer work, no scholarships, no opportunities to grow. It doesn't matter how many people tell me this is not true. I have tried every one of the above with negative results.

The Capstone Design Requirement. Some of the projects that have been used in CE 486,[26] the department's senior level Engineering Design course are as follows. Fall semester of 1994 students conducted a study of a breached earthen dam in Indiana. In the area where water flows over the front of the dam in question, two high pressure pipelines were buried. The level of erosion presented a risk of explosion at this site. The students' objective was to design a way to repair the dam. They were also required to develop a wetlands area near the site of the dam to protect the fish and wildlife habitat. This project provided students with an opportunity for many different forms of creativity as well as a chance to focus on the ethical dimension of the practice of engineering, in this case on the environment (i.e., this particular project was intended to be ecology-oriented.). Each semester, a guest lecturer is also brought into this class to introduce students to the practical issues related to the Engineering Code of Ethics. The lecturer also demonstrates the fine line that sometimes exists between professional ethics and legal liability.

A second project required students to design a runway and a hangar for an airport in Western Iowa. They addressed issues of noise pollution and run-off. The overall objective was to design a way to protect a small town from noise pollution and to solve drainage **problems.**

A third project involved the Iowa 4-H camp. Students were required to design (1) a sewage system and (2) a water filtration system. They were also required to (3) develop a plan to provide access to roads in the area where there was no current access and (4) begin planning site locations for a new multi-person housing area near the camp.

Finally, students focused their efforts on the *Boone Scenic Valley* railroad. In a structures related project they designed a round house[27] from different perspectives to compare costs and appearance or aesthetics. This project also involved style considerations. The objective was to retain an early 1900s design, which introduced students to the visual effects of civil engineering

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26 CE 486 exposes students to the engineering design process, case histories of design inadequacies, environmental impact, safety and health in the work place, cost estimating, planning and scheduling, and synthesis of previous coursework using a group project.

27 The round house is where engines are taken at night and where they are fired up for the next days run.

projects as well as the creativity required by engineering practitioners. This type of exposure would also serve to counter the stereotype of engineering as a discipline/profession that is, according to one nonpersister, "void of creativity" and to another, "too rigid to include creativity."

While the CE 486 projects are designed for senior level students, the recommendation is that freshman students could also become involved in civil engineering oriented projects. These activities would help to maintain their interest in civil engineering and raise their levels of self confidence, in preparation for the more rigorous requirements of the senior level design course(s).

- *CE 295, Practice of Civil Engineering Public Sector*[28] could be offered for both freshman and sophomores, or, more preferably, it could be offered at each level to maximize student exposure to the profession at a time when the department is at the highest risk of losing them to other Colleges within the university.

When students enroll in CE 295, a one-credit required course, they are exposed to engineering practitioners throughout the semester. Speakers from both the public and private sectors are brought in each week to talk to students about topics that have included engineering ethics and liability issues that confront civil engineers. Students do not take this class, however, until they are sophomores. By this point, the department has already seen a number of students change majors, particularly women and minorities.

Students are also exposed to resume writing skills designed to assist them in securing summer employment that is related to civil engineering. Student feedback on resume writing has been positive. They say summer employment provides an excellent opportunity to understand (from a practical point of reference) how to apply some of the engineering principles they learn in the classroom. Exposing students to civil engineering at both the freshmen and sophomore levels might well serve to control for the current attrition rate, particularly for those students who are unsure of what a civil engineer is.

CE 295 faculty have traditionally brought in speakers from the Iowa DOT to talk to students. An expanded focus on the different districts, offices, and divisions within the Iowa DOT in this one-credit course could be justified because civil engineering is designed, in part, to prepare its students for employment in the public sector. The Iowa DOT would have a vested

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28 Iowa State University Catalog. Course description of CE 295. Private and public practice of civil engineering in various agencies of government and in private practice, continuing education, professional ethics, and personnel recruitment. Various civil engineering projects are presented, discussed, and visited.

interest in this effort because, as it was pointed out in Chapter I of this report, agencies can expect to hold on to their 17% share of civil engineering graduates nationwide.[29]

Recent speakers from the DOT have included experts on road design and airport construction. To enhance student interest in these areas, the faculty member in charge of the course brought in speakers who had been former CCE students at Iowa State. Use of former students, who have been on the job a relatively short period of time has been shown to be an effective recruiting tool for employers.

Student Involvement in Engineering Organizations as a Retention Tool

In order to feel as if they are a part of the engineering community, students need to become involved with the events and activities that are sponsored by their College and departments. As Landis comments

> the highly involved student devotes considerable energy to studying, spends a lot of time on campus, participates actively in students organizations, and interacts frequently with faculty members and other students . Conversely, an uninvolved student may neglect studies, spend little time on campus, abstain from extracurricular activities, and have little contact with faculty members or other students.[30]

Results of Item on Student Involvement with Engineering Organizations. The following question was asked of all persisters and nonpersisters.

> As an engineering student at Iowa State University are you/were you actively involved in any Engineering Societies or Organizations?
> 1. Yes
> 2. No

Nearly 50% of Caucasian male persisters said they actively participate in some engineering organization(s), and 66.9% of women also said they do. For minority persisters, however, the number dropped to 28.2%. When nonpersister Caucasian women were enrolled in an engineering curriculum, 39.9% (13 out of a total of 45) belonged to an engineering organization, but only 7.7% of Caucasian men (7 out of a total of 112) and 26.7% of minorities (4 out of a total of 15) belonged. If evidence yielded from Landis' research can be applied to this study, the lack of involvement of minority students may account <u>in part</u> for their high attrition rate. This may mean

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29 See AASHTO (1990), p. 33.

30 See Landis, p. 757.

that the College, the CCE Department, and upper division peers should become involved in developing an action plan to involve all students in student related engineering activities.

Although the recommendation for minority nonpersisters is highly speculative because the sample size is so small (N = 7) four of six (66.7%) CCE minority persisters said they were active in engineering societies. A telephone call to all minority students within CCE could yield additional information as to whether they are currently involved, and if not, why not. Nearly all studies reviewed for this project yielded evidence that the level of involvement in the engineering program was integrally related to retention rates for minorities, in part because this influences the amount of time they spend on campus. Francis et al. reported that it is assumed

> the degree to which students are able to integrate into the campus culture will also be directly related to their academic achievement.[31] If it can be shown that the extent of student assimilation into the institutional structure of the College significantly affects their academic success or failure, then some consideration must be given to the analysis of the implementation of policies that attempt to integrate students into a school's social and cultural life.[32]

The level of integration is contingent in large part upon the intensity of student involvement.[33] While Ainsworth's conclusion is aimed at the retention of minority students, his premise appears in most literature reviewed for this study and thus could be applied to Caucasian men and women as well. This involvement of students in their programs was expressed by one woman persister as follows:

> I have not found a mentor in my major because I have not yet met any faculty to whom I can relate. Currently, I am friends with a graduate student in my program, but don't quite feel the "mentor" relationship with her because she is relatively inexperienced. I feel this "mentor" relationship can be very effective in retention of students -- it makes them feel appreciated. In the past I have always performed better when I had a mentor I could talk with about academic issues. I hope soon I will be able to find someone who can fill this role.

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31 Francis, Kim C.; Kelly, Robert J.; Bell, Martha J. (1993). *Educational Evaluation and Policy Analysis, 15(4)*, p. 437-441.

32 *Ibid.*, p. 440.

33 Ainsworth, Enrique. (1985). *Developing faculty involvement*, chap 14 in *Handbook on Improving the Retention and Graduation of Minorities in Engineering.* R.B. Landis (ed.), National Action Council for Minorities in Engineering, New York.

Because so many engineering persisters are involved in engineering societies at Iowa State, it might be suggested these organizations are effective tools for the retention of students. The item to which students responded is as follows:

The engineering student societies and organizations are effective in providing support for students in engineering programs. These serve as effective retention tools.

1	2	3	4	5	6
Very Strongly Agree					Very Strongly Disagree

Nearly 71% of Caucasian men persisters, 79% of women and 69% of minorities said that student organizations and societies were somewhat to very effective as tools for retention. For nonpersisters, those numbers were similar. Nine of 15 (73.3%) of minorities, 42.3% of Caucasian men, and 28.9% of women indicated they somewhat to strongly agreed that student organizations were effective retention tools for the College of Engineering. While these numbers are encouraging, they do not explain why 50% or more of students drop out of their engineering programs prior to graduation. Other factors may well play an important interactive role in this complex decision.

Mentors and Peer Groups.

The lower ranking for the importance of mentors for both persisters and nonpersisters is likely attributable to the lack of a formalized mentor program within the College. Whether those mentors who do serve are faculty or upper division peers, these interactions can significantly influence a student's academic performance. For minorities, the cultural isolation that emerges if they are not involved may lead them to (1) miss out on the benefits of sharing information and group study with their peers and (2) increase the likelihood they will incur the negative peer influences of friends who are not pursuing demanding academic work.[34] These findings have been affirmed in research that has shown minority students tend to interact less often with their peers. The lack of minority student involvement with mentors or peers may also have been a significant factor for nonpersisters responding in this study.

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[34] *Ibid.*

Thirty-seven percent of minority persisters, for example, said peer groups were not important for them. Sixty-seven percent of nonpersisters agreed they were not important. Student responses could be a reflection of minority student's cultural isolation from their peers within the College, particularly from other minority students. Responses indicating a lack of peer group involvement could also be a function of minority students' inability to realize the importance of peer group involvement in their success in engineering. Their lack of maturity may have thus prevented them from understanding the need to broaden the scope of their reference groups through more active participation in their education, including involvement in engineering organizations.[35] As Landis notes,

> students typically join student organizations because they are encouraged to do so by others. If minority students have less interaction with students and faculty, they will be less likely to be actively involved in student organizations having predominantly non-minority membership.[36]

Landis says student involvement is the key to success in engineering and that these isolation factors are integrally related to the level of energy that minority students devote to studying.[37] As iterated in Chapter III, the intensity of student involvement has been shown to inhibit students from developing good time management skills, self discipline, and a positive attitude. It may also have a negative effect on their use of peer group support and may help to explain the relationship between these factors and their lack of involvement in student organizations and societies. This study shows that for persisters as a group nearly all indicated they believed time management skills were somewhat to very important in their pursuit of an engineering degree.

Of the 664 persisters, responses about time management skills were consistent across both sex and race categories. All persisters also agreed that a positive attitude and self discipline were more important than peer group support and study groups (See Table 4. Table 5 shows this breakdown for nonpersisters). The lack of study group involvement may in turn have an effect on students' abilities to develop the time management skills needed to meet the rigors and demand of

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35 Landis, Raymond B. (May 1988). The case for minority engineering programs, *Engineering Education*, pp. 756-761.

36 *Ibid.*, p. 758.

37 *Ibid.*, p. 758.

the engineering curriculum, which may then have an effect on (1) self discipline, (2) a positive attitude toward engineering studies, and/or (3) motivation to work in study groups.

Table 4. Persisters. Responses to: how important the factors presented in Table 4 are as students pursue an engineering degree at Iowa State University. For each item, the total number of valid responses was: Men; N = 421; Women: N = 210; Minorities: N = 46.

Item	Men	Women	Minorities
Time Management	92.90%	91.00%	95.70%
Self Discipline	96.00%	91.40%	89.40%
Positive Attitude	94.10%	91.40%	89.40%
Study Groups	52.50%	61.00%	68.90%
Mentors	50.90%	47.80%	66.70%
Academic Preparedness	71.00%	78%.00	89.10%
Peer Groups	46.60%	59.90%	63.00%

Table 5. Nonpersisters. Responses to: how important the factors presented in Table 5 are as students pursue an engineering degree at Iowa State University. For each item, the total number of valid responses was: Men; N = 1101; Women: N = 44; Minorities: N = 15.

Item	Men	Women	Minorities
Time Management	38.0%	50.00%	66.70%
Self Discipline	40.0%	54.40%	73.30%
Positive Attitude	78.2.0%	90.90%	86.70%
Study Groups	15.00%	27.90%	35.70%
Mentors	18.00%	37.20%	42.90%
Academic Preparedness	36.10%	46.50%	53.30%
Peer Groups	30.00%	47.70%	33.00%

It is recommended that the College should also consider developing an action plan designed to demonstrate to its Caucasian men the importance of involvement in their engineering education. To reiterate, the overall attrition rate for this latter group is also high, at 50%.

Student-Faculty Interactions

The Advising Factor. Two Caucasian male nonpersisters commented as follows on the advising system:

> I had a strong feeling that advisors and faculty had much more important things to do than to help me. I feel that if someone would have just sat down and helped me to understand what to expect from the engineering program and to put the program into perspective that I would have remained. When I finally did change my major, I felt like I was a failure, unmotivated, stupid, and generally not worth much. The engineering program did not provide the support I needed.

> I think my main problem was a loss or lack of motivation because of the fact that I had never really considered what I wanted to do. Even in my major, I am running into the same problems of not really caring and not understanding and questioning my choices. I don't feel the engineering college failed me; I just found myself bored and uninterested in it.

One woman persister said, "I know when my professors took an active interest in me and my course of study, I felt that I had an extra support group. It made a world of difference." Other women persisters, however, commented as follows:

> I like Iowa State, but at times I have simply felt engineering is not overly friendly for women, or even for those of who don't learn quickly. Most of the time I felt competent in my major but it's just those few times when faculty and even students treat you as if your 're not worth the trouble to try and help. The underlying problem is understanding. Not everyone has the same abilities or backgrounds and that needs to be addressed and taken into account when dealing with us as people.

> Understanding and support from any member of the engineering faculty are important. I realize advisors are not counselors, but if you really do want people to stay in the engineering College, you might encourage the advisors to personalize their interactions with students whether they are doing well or struggling in classes. Poor grades do not always reflect stupidity, but perhaps just discouragement.

A woman nonpersister expressed the following concern,

> I was only in engineering until October of my first semester as a freshman. although I didn't have a problem until I had already decided to switch majors, I had a very disagreeable experience with the Engineering advising staff. When I went in to get the paperwork started on the switch, I was told by the advisor that I shouldn't switch because "a bright young girl" such as myself doesn't

really know what she wants. That was a patronizing comment.

Yet another said, "My advisor was more concerned about losing a woman engineering student than she was interested in my problems."

Since 1973, many studies have reported that engineering is a less than receptive environment, providing little support for women who choose nontraditional careers. For both women and minorities, the lack of peer support systems and effective networking opportunities serve as barriers to retention.[38] Fulco and Dallaire's advice was (1) to bury the stereotyped image of the woman engineer, (2) maintain an open rather than a tradition-bound mind on what can or cannot be handled by women; and (3) treat all students as the aspiring professionals they are, letting their success depend upon their individual performance, not on their gender.[39] As it can be seen by the above student comments, in 1993, women were still reporting that stereotypes were prevalent and the environment was often less than receptive to some women. Women engineering students are responding accordingly, some with a low degree of self confidence even when they are highly qualified to succeed in engineering.

Many say they need to know faculty will be supportive both in and out of the classroom. As it can be seen from Tables 6 and 7, Caucasian male and women persisters say they have that support regardless of sex or race, while nonpersisters report less support. Minorities are much less likely than the other two groups to agree they are satisfied with the advising system. As such, minorities are also less likely to say that advising is an effective retention tool.

Even though women tend to be personally satisfied with their advisors, they, too, do not view advising as an effective retention tool for the College. Perhaps this is a problem, in part, of how the role of advisor is defined. For many students advisors are expected to be course requirement catalog experts, counselors, confidantes, and friends, available for any role at the students' discretion. This role is not always possible because the teaching and research responsibilities, advising, scholarship (i.e., publishing), and service to the department and to the College are all competing for faculty time. If, however, the College is going to improve its record

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38 Baum, Eleanor. (December 1990). Recruiting and graduating women: The underrepresented student, *IEEE Communications Magazine*, p. 47-50; Mallinckrodt, Brent. (January 1988). Student retention, social support, and dropout intention: Comparisons of black and white students, *Journal of College Student Development*. p. 60-64.

39 *Ibid.*, p. 57.

on retention, particularly for women and minorities, this research suggests the reward system for faculty advisors will need to be reassessed.

Table 6. Student persisters who said they somewhat agreed to strongly agreed with items listed.

Persisters	Men	Women	Minorities
Satisfied with Academic Advising	73.30%	78.80%	28.60%
Supportive faculty in the classroom	72.90%	78.70%	80.00%
Supportive faculty outside the clasroom	73.90%	75.70%	73.90%
Advising is an effective retention tool.	61.10%	33.30%	49.20%

Table 7. Student nonpersisters who said they somewhat agreed to strongly agreed with items listed.

Nonpersisters	Men	Women	Minorities
Satisfied with Academic Advising	45.40%	44.40 %	53.00%
Supportive faculty in the classroom	41.80%	43.20%	46.70%
Support of faculty outside the clasroom	39.10%	39.50%	46.70%
Advising is an effective retention tool.	36.70%	42.20%	46.70%

Parental Support

Support and encouragement from family rank high as predictors for women's success in engineering. Research shows, for example, that "more than one-half of women who are working engineers or students in engineering have at least one family member who is an engineer."[40] Baum comments that this seems to be an indication that encouragement to even enter an engineering curriculum requires knowledge about its opportunities and its challenges beyond that learned from high school teachers and counselors.[41] Students responding to this study also commented on the

40 See Baum, p. 48.
41 *Ibid.*

importance of family and high school teacher and counselor support. Some of those comments are as follows:

> I have watched my father and found what he does to be very interesting. That is the major reason I want to become an engineer. (Woman persister)
>
> I believe in myself. I listen to myself more than anyone and I know engineering is for me. I always have had active support from my peers and family. (Woman persister)
>
> My uncle and my grandfather are civil engineers. (Caucasian male persister)
>
> My family was very supportive of my decision to study engineering. (Woman persister)
>
> My high school chemistry teacher had a very big impact on my decision. Until I took his class I had intended to become a lawyer. But. . . . he had faith in me and he knew I would enjoy engineering and enouraged me all the way. (Woman persister)
>
> I wanted a difficult major to prove to my parents and my peers I could do anything I wanted. (Woman persister).
>
> I have three uncles who are engineers and all my teachers thought I should study engineering. (Woman persister).
>
> My dad is an engineer. It is all I have wanted to do since I was in the 7th grade. (Woman persister)
>
> My father was my biggest influence. He is the one who's always encouraged me the most to give engineering a try. (Woman persister)

Once Caucasian men, women, and minorities enter college, however, that high school and family support system must extend, at least for some students, to include faculty and advisors who can offer both encouragement and affirmation of their ability to succeed even when they are not earning grades of A or B in all of their engineering courses. One woman persister commented she was worried about finding a position upon graduation because she was not an A or even a solid B student, just a student in good standing. She noted, "I know a lot of students whose grades are better than mine. Will that prevent me from finding work?" Comments such as these raise the issue of the degree to which materials presented in engineering courses are over the student's head academically, particularly when their need to know they are doing okay even though they are not 4.0 students is not being met.

Tutors

Those students who expressed concerns about their ability to handle course work in engineering were most likely to have said their problem courses included

- Engineering 160
- Engineering 170
- Calculus 166
- Physics 221

When they sought assistance to make it through these courses, some said they often found tutoring services unsatisfactory. Many said there should be a better screening process for tutors before they are accepted. A number also said tutors were often unfamiliar with course materials and lacked the communication skills needed for effective tutoring. Other criticisms were that tutors were often unprepared and/or unrealiable. Tutors unable to assist students with core courses such as Engineering 170 frustrated them because when the professor is also unavailable there is no where to go to get help. The broadest categories of concern expressed by students were aimed at the Math Department. One woman persister who is a CCE major recommended

> A study center should be set up for students, specifically in civil or construction engineering. This would dramatically boost the peer support, which is extremely effective in retaining students. Black Engineering Building has a room devoted to studying, the Design Center has a Reading Room. Town Engineering has a freezing cold, noisy lobby for its students. Provide us with a lounge open all building hours and it will improve comeraderie tremendously.

This same student said

> I cannot stress how important it is to have instructors who are supportive and encouraging outside of class. So many of my instructors seem to think I am merely annoying them if I come to ask questions during their office hours.

A significant number of both persisters and nonpersisters said they somewhat to strongly agreed that materials presented in some of their engineering courses were over their heads academically. For persisters, this included 50% of women, 42.5% of Caucasian men, and 33.3% of minorities. Of nonpersisters , 80% of minorities, 63.6% of women, and 54.5% of Caucasian men said they somewhat to strongly agreed this was a problem for them. These percentages seem to indicate that an interest in problem solving may not translate into a clear understanding of the content of course work presented by the engineering curriculum.

The Engineers' Fascination with Problem Solving

This study found that the problem-solving aspects of engineering are important to students. For all persisters, for example, 86.1% said problem solving somewhat to very strongly

influenced their choice of a major. For women persisters the percent was also high (84%--176 of 209 responding to this question.). Minority students as well reported this was an important determinant of their choice of major (71.8%). Even for nonpersisters, their initial choice of engineering as a major was somewhat to strongly influenced by its problem-solving aspects (71.8% overall said problem solving was somewhat to very important). When controlling for CCE students, 92% of all of them agreed that the problem-solving aspects of engineering strongly influenced them (this included 91.1% of men, 91.4% of women and 86% of minorities).

GPA: Is it Really a Problem? The results of this study showed that women in the College of Engineering have a slightly higher average GPA (Mean = 3.01) than their Caucasian male counterparts (Mean = 2.88), with minorities holding the lowest (Mean = 2.64) of all groups. A more meaningful reflection of minority GPAs, however, may be that 37.7% of them have GPAs above 3.0. It would be inappropriate to draw definitive conclusions based on such a small sample size, but this finding does stand in direct contrast to some studies which have shown that minorities are less likely to be well prepared to compete in engineering programs because they were not exposed to an adequate background in math and science at the high school level.[42] The data in this study also indicate that of those minorities who begin their college careers in engineering at Iowa State University, a significant percentage are not leaving because of unacceptably low GPAs. Of those students classified as nonpersisters, 28.5% of minorities, 33% of women, and 26.4% of men who left the College of Engineering did so with a GPA of 3.0 or higher. This fact may be cause to move back to the recognition issue raised in early in this Chapter.

Even though many women and minority students are leaving the College of Engineering for other majors, their grade points, a majority of minorities (80%, N = 12 of a total of 15) and women (63.6%, N = 28 out of a total of 45) report their engineering course work was over their heads academically. Caucasian men (54.5%, 61 out of a total of 167) also report, however, this is a primary reason why they leave the College. (See Figs. 1-3). This result, too, is inconsistent with the literature which reports that women, more so than Caucasian men have unrealistically high expectations of their performance and leave engineering with significantly higher grade points.

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[42] Forbes, Lincoln, H. and Johnson A. Edosomwan. (September 1990). The role of women, minorities , and the handicapped in the engineering sector, *Industrial Engineering*, pp. 47-49.

Conclusions

The focus of this chapter has been on obstacles to retention of engineering students. Researchers emphasized the CCE Department because it is civil engineering graduates who become candidates for public sector engineering positions. The research shows that one of the primary obstacles facing the civil engineering profession is its lack of visibility. It is this problem that is integrally related to some of the other reasons students give for dropping out of their engineering program. The final chapter of this report will emphasize actions that can be taken both by Iowa State University and by the Iowa DOT to overcome this problem.

Figure 1: Engineering material is "over my head" academically. (Persisters)

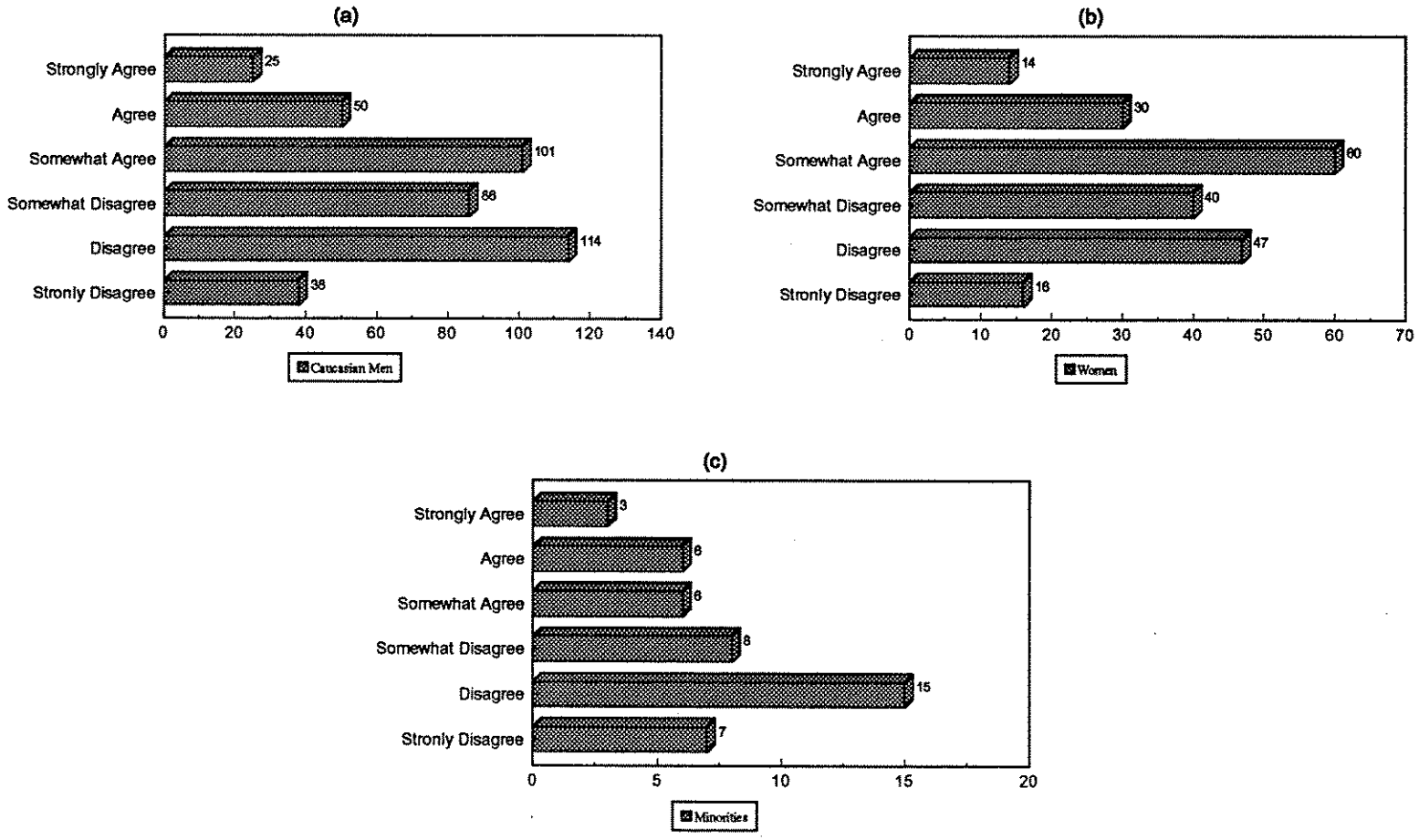


Figure 2: Engineering material is "over my head" academically. (Nonpersisters)

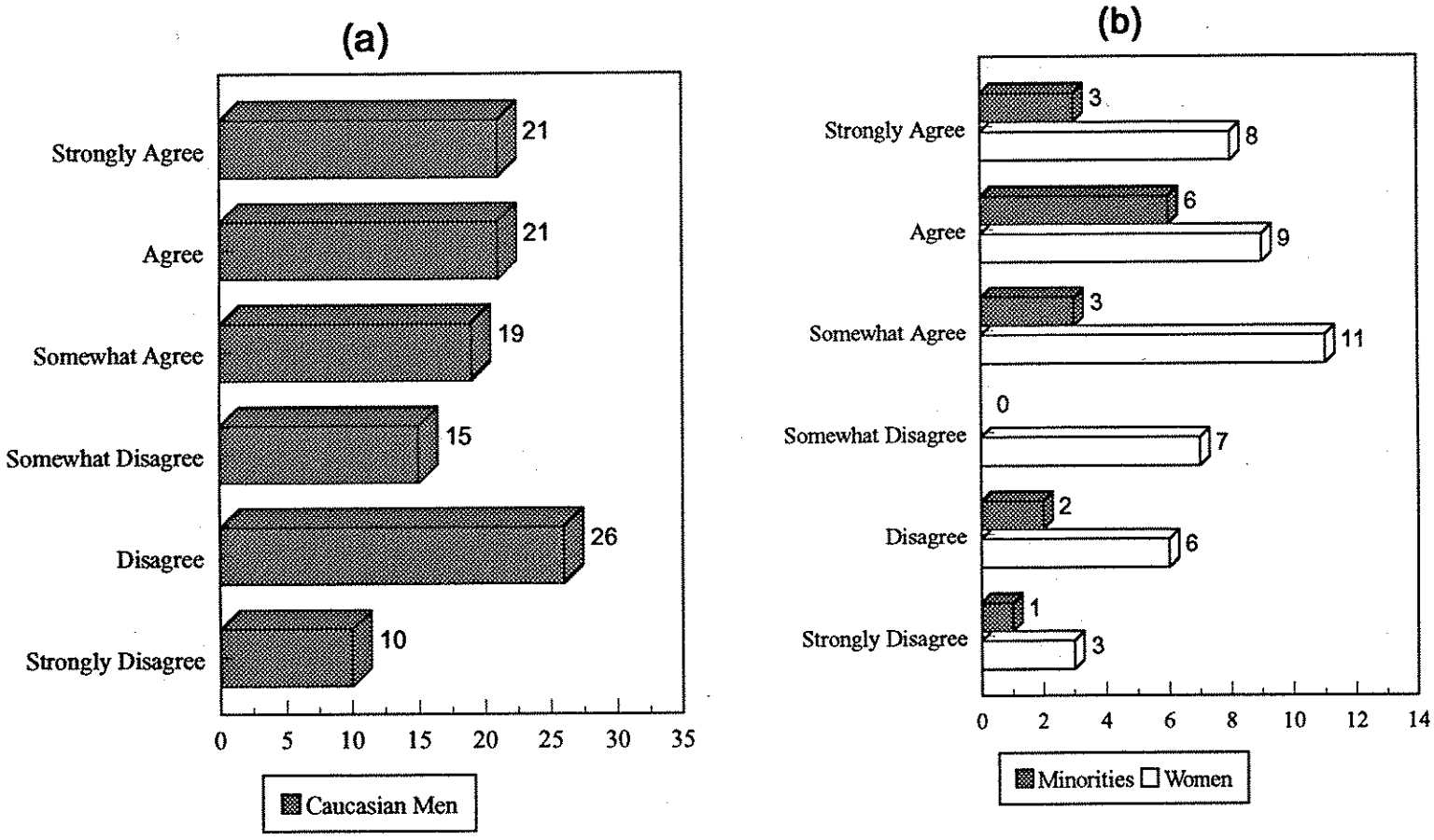
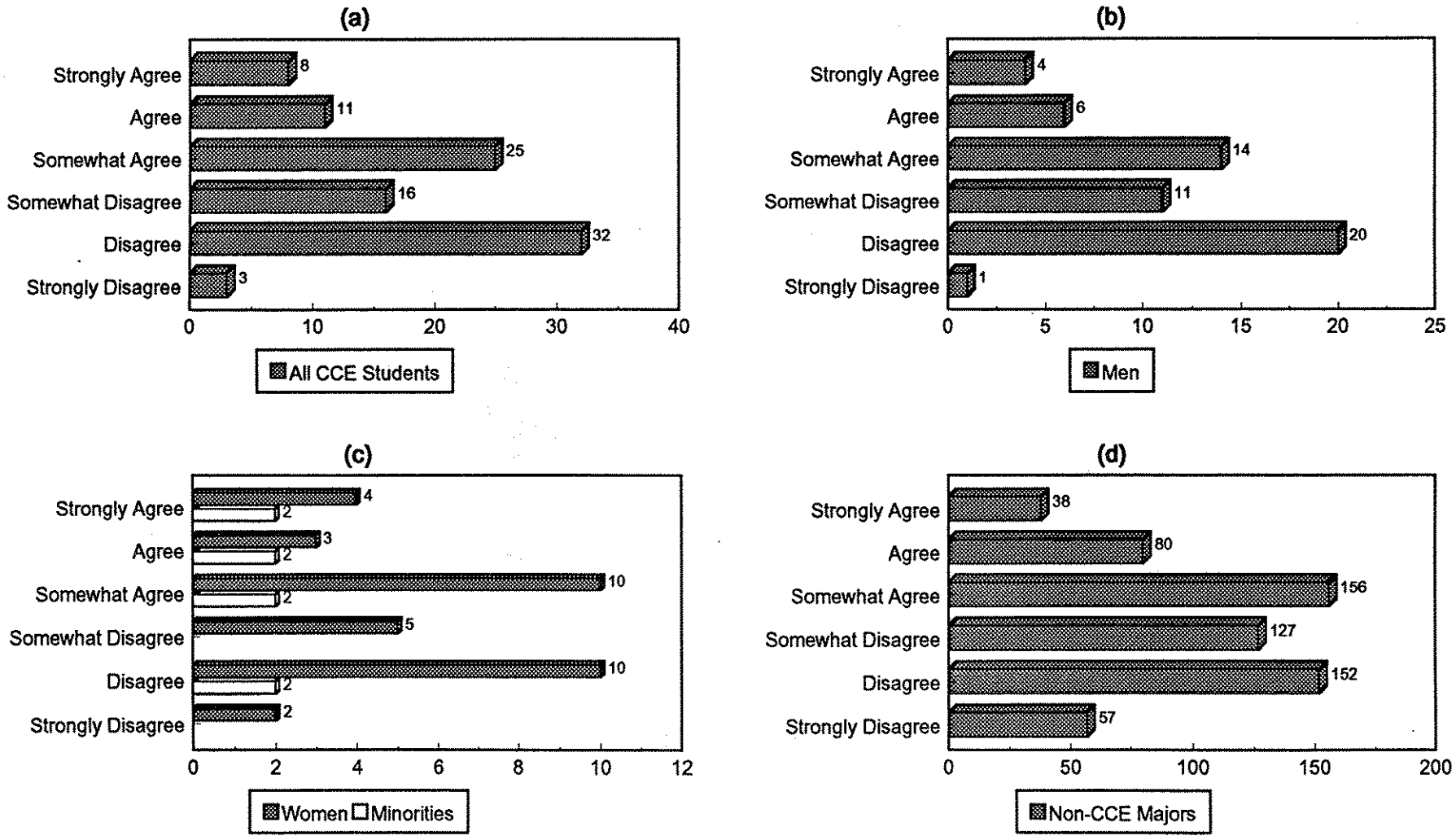


Figure 3: Engineering material is "over my head" academically. (CCE Students Only)



Chapter VI

Conclusions and Recommendations

Strengthening the Iowa DOT and Iowa State University Connection

The Iowa DOT has projected that the following skills will continue to be needed by engineers:

- structural engineering
- design engineering
- construction engineering
- materials engineering and inspection.

Additional projections indicate that enhanced levels of skills will be needed in the areas of

- planning and programming
- management and supervision
- enhancement of writing, speaking, and interpersonal communication skills

Moreover, there will be an increased emphasis at the agency level on

- employee teamwork
- working smarter
- mentoring
- retention of long term employees (i.e., those who have been with the agency for three years and beyond
- ongoing educational opportunities and career development programs that accent
  1. employee growth
  2. recognition of employees
  3. employee advancement training
  4. accelerated leadership programs for agency employees
- engineering management skills, and
- tuition reimbursement for agency employees for individual courses or toward advanced degrees.

As much of its current work force phases out due to retirements, deaths, and career changes, many opportunities will likely be available for Iowa State's graduating engineers.

Overcoming the Recruitment Dilemma.

As it was pointed out in the interim report for this project, there are no easy answers to employee resistance to affirmative action. Some transportation experts, nonetheless, argue that creating a work culture that includes increased numbers of women and minorities is not just the right thing to do, it is the only thing to do.[1] Studies point to the Workplace 2000 Report that predicts a decrease (to 15%) in the number of Caucasian men who will be entering the work force by the year 2000, and an increase (to 30%) for minorities, and (more than 60%) for women.[2] This does not, however, eliminate the stereotype that equal employment opportunities are tantamount to preferential hiring practices.

The often negatively perceived image of equal employment opportunity will begin to dissipate only when an increased level of competition, including highly qualified applicants of both sexes and all races is achieved. It will be important that those selected for available positions are chosen only because they are the best qualified for the job, not because their hiring represents efforts at gaining a diversity balance by mandate.[3]

If this approach is not taken, the public sector, including the Iowa DOT, may be faced with a morale problem that affects productivity and employee relations, or at worst, loss of some of the more experienced engineering personnel currently employed. According to DOT engineers, the problem often stems from the differences in perception employees have of affirmative action guidelines, and equal employment opportunities. The latter are viewed as fair and equitable objectives, the former as a federal mandate. Most agree everyone should have an equal chance for a position, but when the word is you shall hire this person because they are a woman or a minority, a problem emerges. One DOT engineer commented he believes the terms affirmative action and equal employment opportunities should not be used together, implying they are synonymous, because they have diametrically opposed meanings.

This type of input from DOT employees is vital. As pointed out earlier, future projections indicate that it is projected that in the future, state transportation agencies are very likely to have a workforce that is skewed toward younger, inexperienced engineers who may well possess

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1 Steven Blake, Diversity Consultant, Transportation Research Board, Washington, D.C.

2 See Mason, Tarris, Zaki, and Bronzini, p. 5.

3 Some DOT engineers commented they hired employees from underrepresented groups because they were under the impression that it was required if these persons applied for positions. This occurred regardless of whether they believed the person was qualified for the position.

state-of-the-art engineering know-how but who will not possess the breadth and depth of experience held by long term employees. If the DOT is to continue to "manage its workforce" with an eye toward all employees, diversity must be a long term objective, designed so the current workforce can adapt, not a short-term reaction perceived as a move toward meeting an affirmative action quota.

Recommendations Derived From Phase One

The following recommendations are derived from one key conclusion drawn in phase one of this study. The objective of working to improve the retention of civil engineering students at Iowa State University is integrally related to the following question. That is,

> Should the Iowa DOT consider actively recruiting engineers from out-of-state?

It was suggested in phase one that out-of-state recruiting would allow DOT administrators to begin to identify and target those geographic regions where increased numbers of women and minority candidates might more likely to be found to fill vacant engineering positions. A related issue that emerged from this recommendation was

> whether in its efforts to broaden its scope of recruiting, the DOT could better assure itself of a larger pool of applicants in general, and gain an edge in hiring more qualified engineers without noticeable preference for either race or sex/gender.

This was an important consideration for currently employed DOT employees. As one engineer commented in this study,

> Iowa is 97.1% Caucasian, but our engineering staff has around 8% minorities . We exceed the percent in the general population base. Also, we have approximately 50% of the registered P.E. women in the state while we employ less than 10% of the registered engineers in the State.

While this person's calculations were somewhat incorrect, he was accurate in saying the DOT has more minority engineers on staff than is reflected in the general Iowa population (18% of a total of 237 engineers are minorities). Of the 40 women residing in Iowa who are registered P.E.s, however, the DOT employs 5% (N = 12). This reflects 18%, not 50% of the total number of 40 women.

The perception of DOT employees appears to be the following: if the Future's Agenda on diversity calls for significant increases of women and minority engineers over the next decade or more and a decrease in Caucasian men who are hired, this agenda is not acceptable. Moreover, as the Future's Agenda is implemented and some increases occur in hiring for engineers drawn from underrepresented groups, employees argue the following: Let those persons be selected from an in-state pool of qualified engineers. Because of the significant number of responses echoing this concern, the focus of this research became an effort to identify obstacles faced by the CCE Department at Iowa State University as it works to improve its retention rates of these underrepresented groups that will become candidates for DOT positions.

What Are the Retention Problems?

Many different emphases could have been taken in this study. Numerous researchers have, for example, shown projected shortages of qualified engineers will serve to undermine the effectiveness of transportation agencies in maintaining the nation's infrastructure.[4] Others argue that the quality of civil engineering students is unacceptably low,[5] or that civil engineering programs draw in few Honors students and even fewer who qualify for scholarships. Finally, many researchers argue that women and minority students are often unprepared to compete and thus succeed in the rigors presented by an engineering curriculum.[6]

This study does not focus on the projected shortages or on the qualifications issues related to women and minorities alone. Instead researchers chose to emphasize student responsibilities and institutional solutions to retention problems. The emphasis was on those problems for which solutions are not only manageable, but which have the potential to provide the pool of qualified in-state engineers sought by the Iowa DOT.

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4 See Mason, Tarris, Zaki, and Bronzini, p. 5; Reuss, M. and Vogel, R. (1989). Attracting Today's Youth to Civil Engineering. *Journal of Professional Issues in Engineering, 115(4)*, pp. 363-368.

5 See ITE Technical Council Committee 2-32. (1990)., pp. 42-48; Sobol, H. (1990). Future Directions in Engineering Education: A View From Industry and Academia. *IEEE Communications Magazine*, pp. 25-29.

6 See Forbes and Edosomwan, pp. 47-49; Landis, pp. 731-737.

Primary Recommendation

A lack of information about engineering, particularly civil engineering, appears to have a significant effect on retention of engineering students, particularly for minorities and women. It is possible that some members of these two underrepresented groups who drop out of the curriculum do not have a realistic expectation about their engineering education. It is, therefore, recommended that more information be made available to students, particularly at the freshman and sophomore levels. This information should involve a joint effort sponsored by the CCE Department at ISU and the Iowa DOT and should involve those components addressed in the Results and Recommendations section of this report.

Corollaries to Recommendation

Developing a Sense of Community

It is recommended that faculty work to familiarize students with the Town Engineering Building and that faculty learn to know students better as they enter the program as freshmen.

As pointed out earlier, some students have no reason to even visit the CCE building until they become juniors. The isolation factor so often presented in the literature could be overcome, at least in part, by providing students with an enhanced opportunity to develop a sense of identity as an aspiring engineer. While this will continue to be difficult to impossible under a voluntary participation philosophy, the following steps could be taken to increase the probability that more students would become a part of the engineering community.

Freshmen should be required to visit upper division design classes in CCE order to gain a clearer understanding of civil engineering as a profession (See discussion on CE 486). They should be strongly encouraged to attend student presentions for these projects. This course uses practical real world design projects where students are introduced to the practical aspects of problem solving. This requirement could remedy the problem for the significant numbers of all who said textbook learning was not sufficient to retain their interest or their motivation to remain in civil engineering.

It is also recommended that the CCE Department offer a freshman course, that parallels CCE 295. This course could be labeled CCE 195: *Orientation to the Practice of Civil Engineering*.

Speakers from the public sector brought in for this course should include Iowa DOT employees whose objective it would be to demonstrate the variety of engineering positions available in the public sector. It would be prudent to use at least some speakers who are ISU graduates because

younger students would appear to identify more readily with them, particularly if they were recent ISU graduates.

Thus, students should be shown the advantages of becoming an engineer in the public sector and the importance of the vital services provided by public sector transportation engineers. Many students say they have declared civil engineering as their curriculum of choice because they are interested in public service. Indeed, one student indicated he wanted to become a civil engineer because it is an honorable profession.

Because the public sector claims a significant share of civil engineering graduates, at least one half of the freshman level course should be devoted to informing students about the applied work carried out by civil engineers. Caucasian men, women, and minority engineers from the DOT should be invited in to present interactive lectures, providing opportunities for students to ask questions. These persons could serve as role models for students. They could also be offered an opportunity to serve as mentors for some of the students. This type of activity appears to be important because the level of students' involvement in their engineering education is a key predictor for retention. Furthermore, such activities might also serve to encourage more students at the freshman and sophomore levels to become involved in engineering organizations and societies on campus. As Landis found, the amount of time students spend on campus involved in engineering-related activities will serve to disassemble some of the barriers to retention.[7]

DOT administrators throughout the agency's hierarchy should be a part of this course so they can speak with students in a classroom setting. The Director of the Iowa DOT could offer a particularly inviting perception of the public sector career path. Students should also be offered similar exposure to engineering practitioners at the sophomore level to maintain their interest in the profession.

Student Organizations and Societies

Upper division peer groups could be established to serve as student mentors for freshmen students.

As it was noted in the results chapter of this report, approximately 67% of women, 92.3% of men, and 80% of minority non-persisters were <u>not</u> involved in student organizations. Peer mentors

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[7] See Landis, p.756.

could be set up to assimilate freshmen students into the engineering culture. These persons could also voluntarily agree to serve as tutors for freshmen students, overcoming many of the complaints lodged against the structure of the Enginering tutoring system. This would be particularly important for minority students because they are so small in number in CCE.

Although a majority of students did not indicate mentoring was important for them as they pursued their engineering degrees, their responses were likely a function of the absence of mentoring opportunities, not of the lack of importance of mentors. Mentorship relations and other campus-related involvement would also serve to enhance students' sensitivity to time management, self discipline, and a positive attitude, all of which were shown to be important for engineering students.

Faculty Advising

> While it would not be realistic nor fair to faculty to assign all freshman students a CCE mentor, those students who may be interested in establishing this type of relationship should be provided with, or even required to spend time talking with faculty regarding career opportunities upon graduation.

An orientation course such as the recommended *CE 195* course could be used to introduce freshmen to all CCE faculty. Each faculty member could present students with a summary of his or her areas of expertise and research interests (i.e., similar to the Student Handbook for graduate students.) . In this way students would be better able to identify the CCE faculty.

As students begin to develop interests in specific areas of civil engineering, they could be encouraged to contact those faculty who share common interests. The common interest factor could also serve as a retention tool. The primary obstacle to implementing this recommendation is that faculty are already working with overloaded schedules including teaching responsibilities, research, and scholarship (i.e., publishing), advising, and College and departmental service responsibilities. If faculty are to be expected to extend themselves even further, a reward system must be created for faculty interested in working more closely with students. Some are already doing so, but intensifying student interaction may well preclude an emphasis on research or publishing. At the same time, however, both this study and others have yielded evidence that the time faculty spend with students both in and out of the classroom <u>and</u> as advisors are critical predictors of retention. It is beyond the scope of this research to recommend a specific action

plan for (faculty) advisors, but it is an issue of importance that should be addressed in future research.

Co-op Experiences and Internships for Interested Students

> One way for civil engineering to overcome its lack of visibility and to produce students who choose this as a life long career path is to offer co-op experiences and internships to a broader scope of students.

For whatever reason, only about 8% of engineering students in CCE currently participate in these applied experiences. A task force comprising CCE faculty, DOT engineers, and representatives from the private sector should develop an action plan focusing on developing internship or co-op experiences in both sectors as requirements for graduation credit. In this way students would have opportunites to realistically compare and contrast opportunities in civil engineering. Because the Iowa DOT carries out contracting with the private sector, even those students who decide to seek employment in the private sector would be contributing to public sector engineering.

All Students?

One minority student reported in this study that his grade point did not seem to be high enough to qualify him for the co-op program and that he had tried every avenue to securing a co-op position without success. A DOT administrator remarked when this project was initiated, however,that he was interested in recruiting students who were (1) committed, (2) had a strong sense of responsibility, and (3) had a deeply ingrained work ethic. His philosophy was that

> It is important to have a work force in place that is motivated to do a good job. While grades are important, they are not the only predictor of productivity or ability."

He also indicated that does **not** always mean the top students. Any students who are in good standing, with a GPA of 2.0 or better should be able to qualify if they can meet a set of criteria that would be designated by a CCE Department and Iowa DOT memorandum of agreement.

Academic Preparedness

While grades are important and some students are unable to meet the demands and rigor of the engineering curriculum, many students leave the College of Engineering for reasons other

than grades. This study shows that whether those students are women, minorities, or Caucasian men, a significant number leave engineering as students in good standing. Also important to note is that the objective of this study was **not** to make an effort to retain all students who initially enroll in the College. The objective was to make the profession's opportunities clear to all students, so that those who leave do not do so because they need a better sense of direction but who justifiably have found other majors that interest them more. Rather the objective was to identify the obstacles other than those related to cultural and gender biases that seem to prevent so many students from completing their degrees in engineering.

Conclusions

The Iowa DOT's Role

Officials expect that a continued increase in population and travel demand will affect transportation agencies nationwide. State transportation agencies can expect intensified levels of public demand for improved transportation services. They can also anticipate demands for the rehabilitation and replacement of the nation's deteriorating infrastructure (including both roads and bridges), especially as these conditions capture frequent media attention and become issues of concern at every level of government.

The deteriorating infrastructure has placed an ever-increasing burden on state governments, some of which are already facing critical budget problems. Leaders in state government are being forced to develop innovative methods to maintain and/or rehabilitate the infrastructure. Responding to public demands will require an increasingly experienced and sophisticated civil engineering work force. As such, transportation engineers in state agencies as well as those contractors and consultants who expect to do business with them can anticipate working in dynamic and complex working environments little resembling those of yesterday or even today.

The skills that tomorrow's civil engineers are going to need will extend far beyond those required for the solutions of purely technical, engineering, and budgetary problems. AASHTO reports, for example, that agencies will need to

> find people with not only up-to-date engineering training but also with the ability to communicate, the desire to interact with people, and the capability to negotiate successfully in the political and public arenas.[8]

During the coming decade the demographic composition of transportation agencies is also expected to shift from a significant number of older, more experienced engineers to an era in which the largest category of employees will be the youngest and least experienced. As the TRB Special Report noted, maintaining organizational cohesiveness and efficiency amid such a shift will require careful attention to management and training techniques.[9] For such agencies as the Iowa DOT, any aggressive move in the direction of diversity balance must be pursued with an eye toward retaining current and experienced employees while at the same time ensuring a successful recruitment policy aimed at maximizing the size of a competitive pool of highly qualified men, women, and minority candidates for entry level positions.

As engineers who leave the DOT because of career changes or retirements need to be replaced, strategies must be considered to maintain the stability of the employment pool. Whether finding qualified civil engineers presents a supply problem or an availability problem is not really the issue-either way, the objective is to develop recruitment mechanisms to achieve a diversity balance that assures both that the most qualified person will be hired to fill the position -- and that remain sensitive to the needs of currently employed, well-experienced employees.

The University's Role

The obstacles to retention of engineering students seem to revolve in large part around the lack of understanding of what engineering is all about and about the lack of student involvement in their engineering education. While many of the reasons women and minorities do not become involved may well be related to race and gender, other factors, particularly the recognition and interest factors that the institution can resolve. Those issues were addressed in this report. Many of the obstacles to retention that are presented in this report are resolvable. As such they have the potential to produce increased numbers of civil engineering graduates who will be qualified to become applicants for DOT engineering positions, making it possible for the Iowa DOT to continue its focus on in-state recruiting.

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8 See AASHTO, p. 33.

9 See Transportation Research Board. (1985).

Appendix A
Student Release Form

CONSENT FORM

To better understand your background, we are asking permission to obtain limited information that is available in university records. All information accessed will be kept in the strictest of confidence. **THIS INFORMATION IS CRITICAL TO THE STUDY IF YOU CHOOSE TO PARTICIPATE. IT WILL MAKE THE RESULTS OF THE RESEARCH MORE MEANINGFUL.**

Please read the following consent statement. **If you agree to allow us to obtain the information mentioned in the box below, please sign below as requested. Your social security number is required to retrieve the needed information.**

In addition to the information I provide on this questionnaire, you have my permission to obtain my ACT file and my GPA from university records. I understand that any information I provide will be kept in the strictest of confidence. I also understand that there will be no way in which anyone reading the results of this study will be privileged to any information that will reveal my identity.

SIGNED _____ **DATE** _____

PRINTED NAME _____

SOCIAL SECURITY NUMBER _____

If you do not want to grant permission for us to obtain the requested information from university files, please sign above and check the following exclusion:

_____ **Please check ONLY IF you are NOT** willing to grant us permission to obtain your GPA and information in your ACT file.

If you would like to receive a summary of the results of this research, please print your name and a permanent mailing address below:

Name _____

Permanent Mailing Address _____

_____

City/State/Zip Code _____

Note: This form will be torn out of the questionnaire booklet when we receive your questionnaire.
If you have any questions regarding this consent form, please feel free to contact Cheryl Moller-Wong at 294-9966 or Karen Zunkel at 294-1684 in the College of Engineering.

Appendix B
Questionnaire

Please respond to the following questions by CIRCLING the number of the response most appropriate for you or by providing written responses where requested. Thank you for your participation, time, and assistance in this research effort. Please note that the number following each question is a code for the question number. This number will be used for data entry purposes only.

PLEASE WRITE YOUR SOCIAL SECURITY NUMBER IN THE SPACE PROVIDED:

_____ - _____ - _____. THIS WILL BE USED FOR DATA ENTRY PURPOSES ONLY AND WILL IN NO WAY BE USED TO IDENTIFY YOU INDIVIDUALLY.

What is the highest degree you anticipate completing? [001]

1. Bachelors
2. Masters
3. Ph.D.
4. Other [e.g., professional degree such as law. Please specify] _____

What is your current academic major _____. [002]

No abbreviations please

As of this fall semester, are you a . . . . . [003]

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

What is your sex? [004]

1. Male
2. Female

Are you . . . . [005]

1. Married
2. Single [i.e., divorced, widowed, never married, etc.]

Which of the following depicts your racial background? [006]

1. Caucasian
2. Hispanic American
3. African American
4. Native American/American Indian
5. Asian American
6. Other [Please Specify] _____

What is the approximate size of your graduating class in high school? _____. [007]

What is your father's highest level of education? [008]

1. High school education
2. Technical school education
3. Bachelor's degree
4. Master's degree
5. Ph.D.
6. Other [i.e., professional degrees such as law, pastor, or medicine. Please specify]

_____

What is your father's occupation? [Be specific] _____. [009]

What is your mother's highest level of education? [010]

1. High school education
2. Technical school education
3. Bachelor's degree
4. Master's degree
5. Ph.D.
6. Other [i.e., professional degrees such as law, pastor, or medicine. Please specify]

_____

What is your mother's occupation? [Be specific] _____. [011]

How many **hours per week** are you employed **this fall semester?** [012]

1. Not employed
2. 1-10 hours per week
3. 11-20 hours per week
4. 21-35 hours per week
5. more than 35 hours per week

Circle the letters of the responses that accurately reflect the math/science background you completed in high school. **Please circle all that apply.** [013]

1. Algebra I
2. Algebra II
3. Analytic Geometry
4. Calculus
5. Chemistry
6. Physics
7. Other [Please specify] _____

Did you participate in a **pre-college engineering program in high school?** [014]

1. Yes
2. No

If yes, what was the program titled? [015]

_____

_____

As an engineering student at Iowa State University, are you actively involved in any **Engineering Societies Or organizations?** [016]

1. Yes
2. No

If yes, please specify which societ[ies] or organizations you belong to [i.e., Institute of Electronic and Electrical Engineers, American Society of Civil Engineers, National Society of Black Engineers, Society of Women Engineers, Association of General Contractors, Tau Beta Pi, Chi Epsilon, etc.] [017]

_____

_____

_____

Which of the following engineering services do you know about and/or have you used as an engineering major at Iowa State University?

1. IN THE FIRST COLUMN of the three columns provided below, CHECK ANY OF THE FOLLOWING SERVICES OF WHICH YOU ARE AWARE.

1	2	3	
			Student Counseling Services [018]
			Program for Academic Skills and Services [019]
			Psychology 131 - study aid course [020]
			Departmental Help Centers [021]
			Tutoring Services [022]
			Tau Beta Pi - Free Tutoring [023]
			Minority Student Affairs [024]
			Student Employment Services [025]
			Job Placement Office [026]
			Women in Science and Engineering [027]

2. Go back to these same services listed above. In the second column provided, CHECK ALL SERVICES YOU HAVE ACTUALLY USED.

3. Go back to the services listed above a third time. FOR EACH OF THE SERVICES YOU HAVE USED, INDICATE YOUR SATISFACTION WITH THE SERVICE BY PLACING THE APPROPRIATE NUMBER FROM THE FOLLOWING SCALE IN THE THIRD COLUMN. DO NOT RANK THOSE SERVICES YOU HAVE NOT USED.

1 -- I used this service and was very satisfied with it.
2 -- I used this service and was somewhat satisfied with it.
3 -- I used this service and was somewhat dissatisfied with it.
4 -- I used this service and was very dissatisfied with it.

Please comment on your responses to any of the items listed in the box above. [028]

How much did each of the following factors influence you at the time you chose engineering as your major? Use the following scale.

1	2	3	4	5	6
No Influence					Very strong Influence

Earnings potential [029]	1	2	3	4	5	6
Prestige of being an engineer [030]	1	2	3	4	5	6
Professional challenges of engineering [031]	1	2	3	4	5	6
Problem solving aspects of engineering [032]	1	2	3	4	5	6
Service to others [033]	1	2	3	4	5	6
Making a **contribution to society** [034]	1	2	3	4	5	6
Type of work experiences available [035]	1	2	3	4	5	6
Other (Please specify) _____ [036] _____ _____ _____ _____	1	2	3	4	5	6

Please comment on any of your responses to the items in the box immediately above. [037]

From which of the following sources in the box directly below did you receive active encouragement to study engineering when in high school and/or college? Use the scale provided.

Not Applicable [NA]	1 Never	2	3	4	5	6 Always

High school or undergraduate interns [038]	NA	1	2	3	4	5	6
College Engineering Honors Workshop [039]	NA	1	2	3	4	5	6
Mother [040]	NA	1	2	3	4	5	6
Father [041]	NA	1	2	3	4	5	6
Sibling [042]	NA	1	2	3	4	5	6
Other relatives [i.e., uncle, aunt] [043]	NA	1	2	3	4	5	6
High school summer camps [044]	NA	1	2	3	4	5	6
Research careers for women [045]	NA	1	2	3	4	5	6
College visits [046]	NA	1	2	3	4	5	6
Pre-College program through my high school [047]	NA	1	2	3	4	5	6
Summer enrichment program [048]	NA	1	2	3	4	5	6
High school teacher [049]	NA	1	2	3	4	5	6
High school counselor [050]	NA	1	2	3	4	5	6
College recruiters [051]	NA	1	2	3	4	5	6
Friends and peers [052]	NA	1	2	3	4	5	6
Student speakers who are engineering majors in college [053]	NA	1	2	3	4	5	6
Other [Please specify]_____ [054] _____ _____ _____	NA	1	2	3	4	5	6

Please comment on your responses to any of the items in the box above. [055]

For the following section, circle the response that most accurately reflects your perception of the YOUR EXPERIENCES IN YOUR ENGINEERING MAJOR. **Use the scale provided below.**

1	2	3	4	5	6
Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree

ACADEMIC SATISFACTION

I am able to enroll in classes required for my engineering major. [056]	1	2	3	4	5	6
I am satisfied with my academic performance [grades] [057]	1	2	3	4	5	6
I am satisfied with the quality of teaching. [058]	1	2	3	4	5	6
I like the content of courses. [059]	1	2	3	4	5	6
My engineering degree program offers me sufficient opportunities to take electives [060]	1	2	3	4	5	6
I am satisfied with the amount of work required. [061]	1	2	3	4	5	6
I enjoy the challenge of the work required. [062]	1	2	3	4	5	6
I feel the materials presented in some of my engineering classes are over my head academically. [063]	1	2	3	4	5	6
I usually find no difficulty identifying friends/peers to study with. [064]	1	2	3	4	5	6
I experience[d] success in my required math classes. [065]	1	2	3	4	5	6
I experience[d] success in my required chemistry classes. [066]	1	2	3	4	5	6
I experience[d] success in my required physics classes. [067]	1	2	3	4	5	6
I experience[d] success in my required and elective engineering classes. [068]	1	2	3	4	5	6
I experience[d] success in my elective classes [069]	1	2	3	4	5	6
Academic advising is satisfactory in engineering. [070]	1	2	3	4	5	6

Please feel free to comment on any of your responses to items in the box above on academic satisfaction. [071]

Please indicate the degree to which you agree with the following statements regarding your **EXPERIENCES IN MATH, SCIENCE, AND ENGINEERING COURSES**. **Use the following scale.**

1 Strongly Agree	2	3	4	5	6 Strongly Disagree

When I receive[d] a poor grade, I usually feel the main reason is because I have not studied enough for the course. [072]	1	2	3	4	5	6
If I receive[d] low marks, it leads me to question my academic ability. [073]	1	2	3	4	5	6
Some of the times I receive[d] a good grade , it is/was due to the professor's less challenging grading scheme. [074]	1	2	3	4	5	6
Poor grades inform me I have not worked hard enough. [075]	1	2	3	4	5	6
In my case, good grades are always the direct result of my efforts. [076]	1	2	3	4	5	6
The most important ingredient in receiving good grades is my academic ability. [077]	1	2	3	4	5	6
In my experiences, once a professor gets the idea you are a poor student, your work is more likely to receive poor grades than if someone else handed it in. [078]	1	2	3	4	5	6
Some of my low grades seem to reflect some professors are stingy with high grades. [079]	1	2	3	4	5	6
When I fail[ed] to do as well as expected, it is often due to a lack of effort on my part. [080]	1	2	3	4	5	6
If I fail[ed] a course, it is because I lack[ed] skill in that area. [081]	1	2	3	4	5	6
When I receive[d] good grades, it is because of my academic competence. [082]	1	2	3	4	5	6
I feel some of my good grades depend[ed] to a considerable extent on chance factors, such as having the right questions show up on an exam. [083]	1	2	3	4	5	6
Whenever I receive[d] good grades, it is always because I stud[ied] hard for that course. [084]	1	2	3	4	5	6
I feel my good grades reflect directly on my academic ability. [085]	1	2	3	4	5	6
Sometimes my low grades are in courses the professor failed to make interesting. [086]	1	2	3	4	5	6
Some of my low grades have been a function of being in the wrong course at the wrong time. [087]	1	2	3	4	5	6
If I work hard enough, I feel I can overcome all obstacles in the path of my academic success. [088]	1	2	3	4	5	6
If I get low grades, I assume I lack[ed] the ability needed to succeed in engineering. [089]	1	2	3	4	5	6
Sometimes I receive[d] good grades only because the course materials are not challenging. [090]	1	2	3	4	5	6
Overall, the factors responsible for my grades in these classes are under my control. [091]	1	2	3	4	5	6
Overall, the factors responsible for my grades in these classes are under the control of other people. [092]	1	2	3	4	5	6
Sometimes my low grades in in these classes are because the professor is unable to relate the materials to students on their level of understanding [093]	1	2	3	4	5	6

As you approached your MATH, CHEMISTRY, PHYSICS, AND ENGINEERING COURSES in your major, how confident were you that you would be able to meet the demands of those courses. Use the following scale:

1	2	3	4	5	6
Very Confident					Very Unconfident

How confident are/were you that you can/could meet the demands of your **math courses** in engineering? [094]	1 2 3 4 5 6
How confident are/were you that you can/could meet the demands of your **chemistry courses** in engineering? [095]	1 2 3 4 5 6
How confident are/were you that you can/could meet the demands of your **physics courses** in engineering? [096]	1 2 3 4 5 6
How confident are/were you that you can/could meet the demands of your **engineering courses** in engineering? [097]	1 2 3 4 5 6

How important have the following been for you as you pursue your engineering program at Iowa State University? Use the scale provided below.

1	2	3	4	5	6
Very Important					Very Unimportant

Time management skills[098]	1 2 3 4 5 6
Self-Discipline [099]	1 2 3 4 5 6
Positive attitude [0100]	1 2 3 4 5 6
Good study habits [0101]	1 2 3 4 5 6
Good note taking skills [0102]	1 2 3 4 5 6
Effective use of the library [0103]	1 2 3 4 5 6
Availability of tutoring services [0104]	1 2 3 4 5 6
Peer group support [0105]	1 2 3 4 5 6
Support of my academic advisor [0106]	1 2 3 4 5 6
Support of faculty in the classroom [0107]	1 2 3 4 5 6
Support of faculty outside the classroom, i.e., when I go in to ask for assistance on assignments. [0108]	1 2 3 4 5 6
Mentors/role models in my engineering major [0109]	1 2 3 4 5 6
Study groups [0110]	1 2 3 4 5 6
Adequate high school preparation for my major [0111]	1 2 3 4 5 6
Support from my mother. [0112]	1 2 3 4 5 6
Support from my father. [0113]	1 2 3 4 5 6
Support from siblings. [0114]	1 2 3 4 5 6

Are there other factors important to you as you continue your progress in your engineering program at Iowa State University? Please comment on these or on any of your responses to the items in the box on the previous page. [0115]

Please rate each of the following. Use the scale provided below.

1	2	3	4	5	6
Very Strongly Agree					Very Strongly Disagree

The advising/registration process for students in my engineering major is effective as a tool for retaining students. [0116]	1 2 3 4 5 6
The engineering student societies and organizations are effective in providing support for students in engineering programs. These serve as effective retention tools. [0117]	1 2 3 4 5 6

Are there other factors that currently serve or that should be adopted as effective tools for retaining students in your engineering major. Please comment on any that you can identify. [0118]

How strongly do you agree or disagree with the following items regarding your perception of engineering?

1	2	3	4	5	6
Strongly Agree					Strongly Disagree

Engineering is really not what I thought it would be. [0119]	1 2 3 4 5 6
My performance in my engineering courses is adequate, but sometimes I wonder if it is really what I want to do. [0120]	1 2 3 4 5 6
I have discovered another major that interests me more. [0121]	1 2 3 4 5 6
I am still unsure of my academic goals. [0122]	1 2 3 4 5 6
I had been thinking about a change in my career goals. [0123]	1 2 3 4 5 6

Please comment on your responses to any of the items above. [0124]

How important would each of the following be if you should decide to change your major from engineering to something else? Use the following scale.

NA [Not Applicable]	1 Very Important	2	3	4	5	6 Very Unimportant

Other responsibilities are too great, i.e., social activities, work, school, etc.] [0125]	NA 1 2 3 4 5 6
Personal problems [0126]	NA 1 2 3 4 5 6
Family problems [0127]	NA 1 2 3 4 5 6
Anticipating a change in marital status/family situation. [0128]	NA 1 2 3 4 5 6
Living/housing/room mate arrangements unsatisfactory. [0129]	NA 1 2 3 4 5 6
Medical problems. [0130]	NA 1 2 3 4 5 6
A disability, i.e., physical, learning, etc. [0131]	NA 1 2 3 4 5 6
Little or no support from family members [0132]	NA 1 2 3 4 5 6
Little or no support from friends and peers [0133]	NA 1 2 3 4 5 6
Too few people with whom I could identify in my major. [0134]	NA 1 2 3 4 5 6
Discrimination in the classroom/community [0135]	NA 1 2 3 4 5 6
Test anxiety [0136]	NA 1 2 3 4 5 6
Inability to attend classes regularly. [0137]	NA 1 2 3 4 5 6
Inadequate study skills [0138]	NA 1 2 3 4 5 6
Tred of low grades [0139]	NA 1 2 3 4 5 6
Classes too large. [0140]	NA 1 2 3 4 5 6
Too little time for social/cultural events [0141]	NA 1 2 3 4 5 6
I cannot find affordable child care [i.e., engineering curriculum demands I be away from home working in study groups to stay on top of my classes [0142]	NA 1 2 3 4 5 6
Athletic commitments take too much time from my studies in engineering. [0143]	1 2 3 4 5 6
I work too many hours outside of classes to keep up with the demands of my engineering curriculum. [0144]	NA 1 2 3 4 5 6
Other [Please specify] 0145] _____ _____ _____	

Please comment on any of your responses to the items in the box above. [0146]

Please feel free to make any other comments you feel may be important to our understanding of your responses to items on this survey. [0147]

WE WANT TO THANK YOU FOR TAKING TIME OUT OF YOUR BUSY SCHEDULES TO PARTICIPATE IN THIS RESEARCH!