National Cooperative Highway Research Program

NCHRP Report 347

Civil Engineering Careers: Awareness, Retention, and Curriculum

Transportation Research Board
National Research Council

National Cooperative Highway Research Program

Report 347

Civil Engineering Careers: Awareness, Retention, and Curriculum

J. M. MASON, JR., J. P. TARRIS, and E. ZAKI
The Pennsylvania Transportation Institute
The Pennsylvania State University
University Park, Pennsylvania
and
M. S. BRONZINI
Consultant

Research Sponsored by the American Association of State Highway and Transportation Officials in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD
National Research Council
Washington, D. C.
May 1992

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

Note: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers names appear herein solely because they are considered essential to the object of this report.

NCHRP REPORT 347

Project 20-24(3) FY'90

ISSN 0077-5614

ISBN 0-309-04870-2

L. C. Catalog Card No. 92-81127

Price $12.00

Areas of Interests
Administration

Modes
Highway Transportation, Public Transit, Rail Transportation, Air Transportation

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation officials, or the Federal Highway Administration, U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

FOREWORD

By Staff
Transportation Research Board

This report describes techniques to promote student awareness of civil engineering as a career option. Also described are methods to enhance awareness for mathematics and science studies in general, as well as programs designed to address employee shortages in other professions. This information along with the results from 17 focus groups was used to identify specific efforts to further the awareness of civil engineering, to retain students already on a civil engineering career path, and to affect curriculums taught in kindergarten through the college level with pertinent civil engineering situations and examples. Accordingly, this report will be of interest to agencies that employ civil engineers and to anyone concerned with the future of the civil engineering profession. Individuals from organizations, such as state departments of transportation, universities, associations, and private firms, will find the report useful for developing and supporting their own programs.

The Pennsylvania Transportation Institute (PTI) at The Pennsylvania State University has completed the first two phases of the three-phase NCHRP Project 20-24(3), "Expanding the Civil Engineering Pool." Although initially responding to indications of a decline in the number of civil engineers, the overall objective of the project grew to include recommendations for actions to increase not only the number of civil engineers interested in transportation careers, but also the quality of those engineers. Additionally, the recommendations take into account the diverse demographics of our future population.

Under the first phase, PTI catalogued and described existing techniques that are now being used to promote student awareness of civil engineering career options and interest in mathematics and science studies. Programs designed to address employee shortages in other professions were studied to benefit from any solutions to similar problems.

As part of Phase I, 17 focus groups were conducted at 4 locations with students (including women and ethnic minorities), teachers, parents, and counselors. The purpose of the focus groups was to gain insight into attitudes on civil engineering as a profession and career option.

Under the second phase and based on the results of Phase I, PTI developed recommendations for a series of actions that apply to kindergarten through college. Recognizing that there are other programs to promote mathematics and science, the degree to which these recommended actions stress civil engineering as a career option increases as the level of education increases. These various actions have been categorized under three themes: *A*wareness, *R*etention, and *C*urriculum, and are now referred to as the ARC model.

At the time of publication, research under the third phase was underway to further advance particular actions in the ARC model by incorporating more specific instruction

on application and implementation. Furthermore, the existing actions and techniques identified in the earlier phases will be presented in a new directory using the ARC framework. Finally, Phase III will result in the publication of a comprehensive "User's Guide."

In addition to the research just described, a unique opportunity has emerged to advance specific portions of the ARC model with the actual development, application, and evaluation of prototype material. A pilot program has been created recently by the American Association of State Highway and Transportation Officials (AASHTO), with principal funding from the Federal Highway Administration and the NCHRP, which is providing financial support specifically to the creative development of prototype material. Several other organizations are also providing financial support or making in-kind service contributions. This pilot program, called the TRAC (*T*ransportation and *C*ivil Engineering) Careers Center, will be engaged in various outreach activities over the next 2 years and will coordinate its effort with PTI.

An abbreviated summary report titled, "Expanding the Pool of Civil Engineering Students: Strategies for Their Recruitment and Retention," has been prepared and distributed by the NCHRP to state departments of transportation. The summary report may be more effective in gaining the interest and attention of top officials in various organizations and associations. Also readers will note that Appendixes A through E have not been published herein. The same material will eventually be included in the Phase III directory mentioned previously. In the interim, the summary report and the full agency report with all appendixes are available for loan or purchase ($5.00 and $10.00, respectively) on request to the National Cooperative Highway Research Program, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, DC 20418.

CONTENTS

ACKNOWLEDGMENTS

This report was prepared by the Pennsylvania Transportation Institute (PTI), The Pennsylvania State University, as partial fulfillment of NCHRP Project 20-24(3), titled "Expanding the Civil Engineering Pool." Dr. John M. Mason, Jr., director of the Transportation Operations Program at PTI and associate professor of civil engineering, served as principal investigator. Other principal authors of this publication include Mr. Joseph P. Tarris and Ms. Eman Zaki, both research assistants at PTI. Dr. Michael S. Bronzini, who was head of the Civil Engineering Department at Penn State when the project began, served initially as principal investigator and later as consultant.

The Brand Consulting Group, Southfield, Michigan, served as the subcontractor that performed the market research study. Mr. Jon Brand and Mr. Milton Brand conducted the focus group sessions and documented their findings as presented in Appendix F of this report.

Other project team members who provided significant guidance, review, and assistance throughout the research effort include several members of the faculty and administration at The Pennsylvania State University: Dr. Peter B. Everett, associate professor of marketing; Dr. Edwin L. Herr, Distinguished Professor and head, Division of Counseling and Educational Psychology and Career Studies; Dr. Mary Kathleen Heid, assistant professor of education; Dr. Daniel C. Davis, director, Minority Engineering Program and associate professor, Engineering Science & Mechanics; and Ms. Sharon Jadrnak Luck, director, Women in Engineering Program. Their expertise and insight helped to establish the central issues of awareness, retention, and curriculum as the focal strategies of future efforts to enhance the civil engineering pool.

Three external consultants served as project advisors: Prof. Harold L. Michael, head, School of Civil Engineering and director, Joint Highway Research Project, Purdue University; Dr. C. Michael Walton, Bess Harris Jones Centennial Professor and chairman, Department of Civil Engineering, The University of Texas at Austin; and Dr. Raymond B. Landis, dean of Engineering and Technology at California State University, Los Angeles. The breadth of their experience created the forum for the evaluation of the initial findings of this study. Their suggestions and critiques likewise provided a screening of potential and feasible alternative action plans. They and their able staffs were also instrumental in recruiting participants for and staging the focus group sessions held at their respective locations.

Others who assisted with the focus group effort include: Charles Vitale, executive director, Pittsburgh Regional Engineering Program; Charles Schubert, president, and William Amrhein, director, Pittsburgh section, American Society of Civil Engineers; and Mary Baylets, administrative aide, Penn State University Civil Engineering Department.

The authors wish to thank the support staff of PTI for their diligent efforts and assistance in producing this report. Special appreciation is also extended to the survey respondents at the various state transportation agencies, academic institutions, professional societies, and other organizations that provided specific information to be compiled in this document.

CIVIL ENGINEERING CAREERS: AWARENESS, RETENTION, AND CURRICULUM

SUMMARY

A review of recent demographic trends and employment facts indicates that the traditional major source for the supply of civil engineers (white males) will only constitute 15 percent of the net new workers added to the labor pool by the end of this century. Ethnic minorities and women together will be the major source of new entrants to the U.S. labor pool. In the civil engineering profession, these two groups are presently significantly underrepresented. Furthermore, the retention rates of the ethnic minorities studying civil engineering are poor. Additionally, while overall college enrollments have held steady during the 1980s, the number of students graduating from high school has steadily declined from its peak in the mid-1970s and is not expected to begin to rise until the mid-1990s. To confound the situation, it is a national expectation that the fastest growing sectors of the work force will be the areas requiring the highest skill levels. It is anticipated that the civil engineering profession will find itself competing for high quality, competent individuals who will simultaneously be considering the appeal of other careers.

To meet the changing needs of the civil engineering work force, this research project has developed a conceptual model (herein referred to as "ARC") that contains three comprehensive and interrelated marketing strategies: (1) Heighten the *Awareness* of the civil engineering profession. (2) Improve the *Retention* rate of the existing pool of potential civil engineering candidates. (3) Enhance the *Curriculum* of pre-college and college programs. These key strategies serve as the focus for a proposed marketing approach that attacks all of the developmental stages of the pool of potential civil engineers.

The overall objective of NCHRP Project 20-24(3) is to identify, develop, and test specific methods that will enhance the supply of civil engineers available to transportation-related organizations and agencies. Supply includes issues of *both* quantity and quality.

The initial research activities included two phases: a data gathering effort (Phase I), and the preparation of a set of action plans that would be considered for further development by NCHRP (Phase II).

This report is divided into two parts. Part 1, the research report, contains the detailed findings of the initial research to identify existing programs and practices to promote the civil engineering profession, and presents the results of 17 diverse market research-based focus group sessions. Part 2 serves as a comprehensive catalog of current efforts by related constituencies and provides a synthesis of practices to increase specific labor supplies.

The research approach used to develop the conceptual marketing strategies and resulting proposed action plans is provided in this report. A supplemental overview report has also been produced that briefly summarizes the overall project activities, concisely discusses the alternative strategies for enhancing the civil engineering pool, and clearly articulates the salient elements of the recommended action plans to be considered for further development and eventual implementation.

Several fundamental obstacles to enhancing the civil engineering pool have been identified in this initial research effort, including (1) an image problem that exists for the civil engineering profession; (2) institutional barriers that contribute to the increasing attrition rates among high school and college students; and (3) the need for changes in the pre-college and college curricula to mitigate these problems.

To effectively address these obstacles, it is proposed that a long-range program be initiated that consists of three interrelated marketing strategies: **AWARENESS + RETENTION + CURRICULUM.**

Additionally, future marketing efforts to enhance the pool of civil engineers must recognize all of the developmental stages of the educational process, from kindergarten through college.

The recommended action plans presented in this report were devised to address specific issues at each defined developmental stage of the educational process. If the "ARC" model is applied comprehensively, the marketing strategies deployed throughout the pre-college developmental stages should minimize the need for additional college-stage actions. Full implementation would ensure an adequate and diverse supply of competent civil engineers to staff transportation organizations beyond the 1990's, and would have the ancillary benefit of producing a populace better informed about the role of civil engineering in society.

Part 1—Research Report

CONTENTS

Chapter **1**

INTRODUCTION

PROBLEM STATEMENT

The concept of supply and demand applies to human resources as well as to traditional consumer goods. The American Society of Civil Engineers (ASCE) reports that the supply of civil engineers graduating with bachelor's degrees each year decreased from 10,547 in 1981 to 7,688 in 1989 (*1*). At the same time, the demand for civil engineering professionals is seen to be on the rise. Several of the predicted growth rates for engineering and civil engineering are as follows.

The Hudson Institute predicts a rate of growth between the years of 1985 and 2000 for engineering/architecture/surveying of 41 percent (*2*). The Transportation Research Board (TRB) estimates that future demand for civil engineers will increase at an annual rate of 5 percent, with 60 percent of the increase due exclusively to growth and the remaining 40 percent resulting from death and retirement (*3*). And the Bureau of Labor Statistics (BLS) projects that the employment of civil engineers will increase 17.9 percent between 1988 and the year 2000 (*4*). If the supply of civil engineers continues to decrease, the required demand will need to be met in an even more highly competitive market.

While some argue that the shortage issue is really one of providing adequate and commensurate compensation, reality demonstrates that this remedy requires a long-term continuous effort. Near-term strategies for recruitment and retention must also consider the emerging demographic changes in the future work force, which will severely curtail the size of the traditional pool of entering students. Additionally, students currently enrolling in civil engineering score lower on the SAT/ACT (Scholastic Aptitude Test/American College Test) examinations than students pursuing other engineering fields, which introduces a student quality dimension into the shortage situation (*5*).

The civil engineering supply pool is shown in Figure 1. Inflow to the pool consists of graduates from the university system, individuals reestablishing their careers, and immigrants. At this time, the number of individuals reestablishing their careers is small. Immigration currently adds approximately 750 to 800 civil engineers to the pool annually (*3*). This population influx is relatively stable, but is always subject to modifications in U.S. immigration policy. The largest supply to this pool, approximately 90 percent, is from the university system.

Outflow from the pool is attributable to death, retirement, individuals electing to pursue a career path other than civil engineering, and individuals electing to place their careers on hold to facilitate educational or family considerations. Currently, approximately 20 percent of graduate civil engineers elect to pursue a career path other than civil engineering (*5*).

The makeup of the U.S. work force is changing with respect to an aging population, low birth rate, population shifts, and increased educational and per capita income levels (*6*). The U.S. Office of Technology Assessment (OTA) predicts that the East and Midwest, in general, will see a decrease of 15 to 25 percent in the number of high school graduates produced. On the other hand, the West and Southwest will see the numbers of high school graduates increase by 15 to 30 percent (*7*). The ramification of all these changes, in sheer numbers alone, is that the size of the traditional college-age population (18- to 24-yr olds) will decrease approximately 25 percent from current levels by the

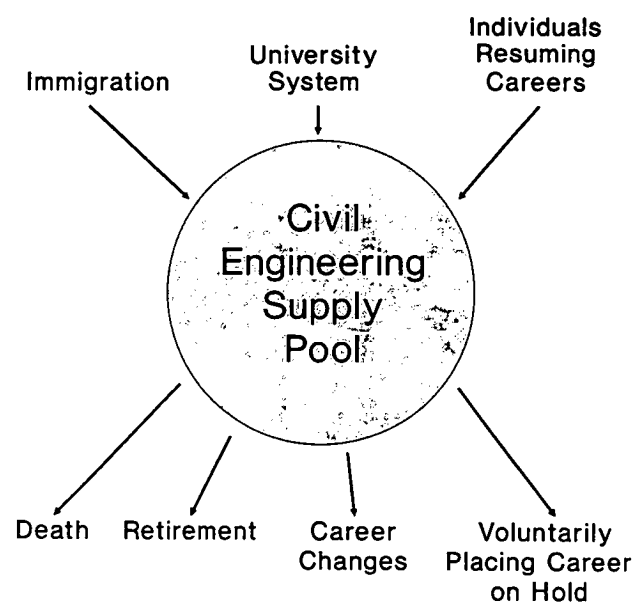

Figure 1. The civil engineering labor supply pool—inflow and outflow.

year 1996. This drop is predicted to reduce college enrollments by 12 to 16 percent (*7*). But the numbers alone do not convey the entire story. Currently, approximately 75 percent of the undergraduate degrees conferred annually are obtained by white males. However, data indicate that this group, while the clear majority, may be a minority in the 21st century (*8*).

Table 1 presents a comparison of the number of civil engineering degrees conferred for 1980 and 1989 in total, for women, and for ethnic minority groups (*1*). The percentage of women conferred civil engineering degrees has increased during this period from 9 percent of all civil engineering degrees to 14 percent. The percentage of African-Americans has remained constant, and Hispanic-Americans and Asian-Americans have shown modest increases. However, women and minorities remain underrepresented relative to their numbers in the population. The OTA attributes this underrepresentation to the following seven factors: (1) the legacy of discrimination toward women and minorities; (2) differential treatment applied on the job, especially toward women; (3) the lack of early educational opportunities for minorities—especially due to economic, social, and cultural factors; (4) female socialization patterns that discourage women from pursuing engineering as a career; (5) the continuing expectation that women will continue to assume the major role in housekeeping and child rearing; (6) the lack of financial support for minorities; and (7) the lack of role models and early exposure (*9*).

Vetter asserts that women's interest in pursuing degrees in engineering is currently declining and that without an active effort this situation will not reverse (*10*). However, other professions, and even other fields of engineering, have obtained relative success in attracting women. In particular, for the medical, business, and law professions, women currently earn 40 to 50 percent of the degrees conferred (*3*).

For African-Americans, the percentage of civil engineering degrees conferred has historically been approximately 2 percent (*3*). As previously noted, for the Hispanic- and Asian-American populations, a modest increase in the percentage of civil engineering degrees conferred was realized during the 1980's. However, the current attrition rate of the minority student in the engineering program is very high. Only about 20 percent of the minority students who begin in engineering ever earn engineering degrees (*11*). Approximately 70 percent of the freshman white male engineering students obtain engineering degrees (*10*).

Table 1. Summary of civil engineering degrees conferred—1980 and 1989.

Group	1980	1989	Percent Change
All	10,346	7,688	-25.7
Women	931	1,036	11.3
African-Americans	158	170	7.6
Hispanic-Americans	257	274	6.6
Asian-Americans	290	353	21.7
Native-Americans	9	28	211.0
Foreign	1,309	864	-34.0

In summary, it appears that the need for civil engineers will continue to grow in the future. However, the reduced levels of college-age individuals in the population combined with the changes in the demographic makeup of this group will make it difficult for the educational system to supply an adequate number of quality civil engineers to satisfy demand. Referring to Figure 1, possible strategies to bolster supply include: changing the immigration law to permit more foreign national civil engineers to establish residence in the United States; encouraging those individuals who elect to abandon civil engineering as a profession not to do so; recruiting and retaining a greater percentage of college-oriented women to pursue civil engineering; recruiting and retaining a greater percentage of minorities to the professional opportunity offered by civil engineering; and recruiting and retaining more civil engineering majors from other portions of the pool of college-bound students.

Efforts to encourage more students, particularly women and minorities, to pursue civil engineering as a profession may be categorized as either supply side or demand side. The demand side involves the improvement of the "product," where the product includes both engineering employment conditions and engineering curricula. The supply side involves increasing the number of students interested in civil engineering and prepared to enter the profession.

The overall objective of NCHRP Project 20-24(3) is to identify, develop, and test specific actions that will increase the overall supply of civil engineers available to the transportation profession. Particular attention and emphasis are placed on the implications of changing demographics on the future work force.

RESEARCH APPROACH

The research approach to expanding the civil engineering pool comprises three phases. Table 2 contains an annotated outline of the key elements of each phase.

Literature Search

A literature review, using standard library sources and bibliographic search services, was accomplished to obtain information on the following subject areas: current practices that are being used to increase interest in civil engineering and the overall supply of civil engineers; current practices that are being used or promoted by professional, industry, and government organizations and agencies to increase interest in engineering, mathematics, and science; practices being used by other professional disciplines to expand their overall labor supply; the knowledge, attitudes, and perceptions of the various constituencies involved in the civil engineering career-choice decision; and the changing demographic make-up of the population.

Table 2. Annotated outline of the key elements of each phase of the project.

I. Data Gathering

1. Document practices used by undergraduate civil engineering and engineering technology programs and State transportation agencies to increase interest in civil engineering and/or civil engineering related careers.
2. Document practices used by other professional disciplines to address their labor shortages.
3. Identify the attitudes and expectations of various constituencies affecting civil engineering career-choice decisions (via intensive "focus group" interviews).
4. Prepare an Interim Report that serves as a catalog of practices used by the civil engineering profession and other professions to expand their labor supply. Also, summarize the early findings of the focus group sessions.

II. Prepare Implementation Action Plan

1. Convene entire project team to review interim findings and identify candidate action plans.
   - Review focus group outcomes.
   - Consider interim report findings.
2. Prepare action plan "write-ups" for increasing the supply of civil engineers.
3. Document phase I and II activities; action plan "write-ups" prepared for appendix.

III. Produce Manual of Selected Techniques

1. Develop, test and refine selected actions.
2. Produce Manual of Selected Actions.

Survey of Practices and Programs to Increase the Pool of Civil Engineers

Numerous professional associations and resource organizations were contacted for relevant information and sample documents and programs. The organizations contacted are given in Tables 3 and 4. Letters of request for samples and descriptions of pertinent materials were sent to 224 civil engineering departments and 114 civil engineering technology departments on record with the American Society of Civil Engineers, and 50 state highway agencies and departments of transportation (DOT's) in the United States. The materials requested included a brief narrative description of policies, procedures, and practices; sample documents, brochures, and pamphlets; published and unpublished writings on the subject; reports of effectiveness or evaluations of current practices; and audiovisual materials for project review.

A second mailing was conducted to increase the response rate. Approximately 100 colleges and universities were sent a second letter to encourage their response, even in the event that the materials requested *did not* exist. State transportation and highway agencies that did not reply to the original inquiry were also contacted. The final survey response is provided in Table 5. The findings are summarized in the following sections of this report; specific details are documented in the appendixes.

Market Research Study

The principal means of field data collection in this study was a market research study designed to determine how people make career-choice decisions and what underlying attitudes and perceptions they have about civil engineering and other professions. A method of qualitative research known as the "depth group" or "focus group" was used. The study was conducted by The Brand Consulting Group, Southfield, Michigan, under the supervision of the Pennsylvania State study team and with the assistance of the study consultants located at the field data collection sites.

As indicated in Table 6, focus groups were conducted in State College and Pittsburgh, Pennsylvania; Lafayette, Indiana; Austin, Texas; and Los Angeles, California. Seventeen sessions were conducted, including separate groups of junior high school, high school, and college students; parents; teachers; counselors; college faculty; and practicing civil engineers. Selected groups consisted entirely of African-American or Hispanic-American subjects, while the balance was ethnically mixed (although predominately Caucasian). All groups contained a mix of male and female participants. All sessions were viewed by at least one study team principal, and all were recorded on both audio and videotape.

The focus group technique is based on a "stimulus and reaction" depth interviewing format rather than on the traditional "question and answer" format. The technique involves approximately 10 people who are led in discussion by a trained moderator. The moderator is skilled at stimulating and probing respon-

Table 3. Resource organizations identified.

American Indian Science and Engineering Society (AISES)
Society of Women Engineers (SWE)
Society of Hispanic Professional Engineers (SHPE)
National Society of Black Engineers (NSBE)
National Association of Precollege Directors (NAPD)
National Association of Minority Engineering Program Administrators (NAMEPA)
National Action Council for Minorities in Engineering (NACME)
Mexican American Engineering Society (MAES)
Los Angeles Council of Black Professional Engineers (LACBPE)

Table 4. Science and engineering societies.

American Association of Engineering Societies
American Association of Physics Teachers
American Chemical Society
American Consulting Engineers Council
American Society of Civil Engineers
American Society for Engineering Education
American Society of Mechanical Engineers
Institute of Electrical & Electronics Engineers
Institute of Industrial Engineers
Institute of Transportation Engineers
National Society of Professional Engineers
The Engineering Society for Advancing Mobility, Land, Sea, Air, and Space
Society of Engineering Science
Society of Manufacturing Engineers
Society of Mining Engineers, Inc.
Society of Physics Students

Table 5. Summary of survey response.

	Number of Departments/Agencies Contacted	Number of Departments/ Agencies Responding
Civil Engineering Departments	224	83
Civil Engineering Technology Departments	114	30
State Transportation/Highway Agencies	50	44
Resource Organizations	9	5
Professional Associations	16	10

dents to uncover each participant's insights. Questions, idea stimuli, concepts, printed brochures, and even video materials are exposed to the participants for their reactions. In the ensuing discussion, the moderator does not "allow" individuals to "answer" with easy, "top-of-the-head" answers. Respondents are challenged. If necessary, actual arguments occur. Once the entire group catches the spirit of the procedure, they generally cooperate with the leader. All begin to challenge each other not to give the first facile answer. Each respondent's attitudes are subjected to the glare of such scrutiny.

The moderator in such a group is stimulated by what people say and will usually come up with "on-the-spot" hypotheses that rationalize the particular behavior patterns being solicited from the panelists. The moderator frequently interrupts a session to present a "summary" of what has transpired to that point. What looks to the observer like "leading" is, in essence, a "feedback" to the group of hypotheses that have been designed to rationalize observed group behavior. Group acceptance of the "summary" as correct serves as an early indication of the validity of the hypotheses.

Evaluation of Phase I Findings

An Interim Report was produced that documented the activities completed under Tasks 1, 2, and 3 of the Data Gathering phase of the project. the Interim Report served as a catalog of practices used by the civil engineering profession, the engineering profession in general, and other professions to expand their respective pool of students and labor supply. Emphasis was placed on identifying those practices that target underrepresented groups (ethnic minorities and women). The report also summarized the findings of the focus group sessions.

The entire project team and the NCHRP project panel critically reviewed the Interim Report. The initial findings were further evaluated during a 2½-day workshop meeting attended by the project team, the project consultants, and the NCHRP project panel. All participants provided their reactions to the Interim Report's findings and to the focus group results. On the basis of written and verbal comments on the Interim Report and the workshop activities, a decision was reached to prepare a comprehensive research report that contained the detailed findings of the Phase I and Phase II efforts.

Documentation of Phase I and Phase II Efforts

This report has been prepared to serve the purpose of fully recording the results and products of the overall project. The research report is divided into two parts. Part 1 summarizes the activities of the overall project, concisely presents the results of the Phase I and Phase II efforts, discusses the strategies advanced for enhancing the civil engineering pipeline, and presents a list of recommended action plans to be considered for further development and eventual implementation. Appendixes A through E present detailed information related to state agency, academic institution, and professional practices to increase interest in civil engineering and closely aligned technical areas. A complete copy of the market research study is provided in Appendix F. Fifteen candidate action plans are provided in Appendix G. Part 2 presents a synthesis of current practices to increase specific labor supplies.

Phase III Activities

The goal of the project is to produce a manual of selected techniques to be used by transportation agencies, educational institutions, national organizations, and others interested in increasing the pool of civil engineers. Phase III will include the development, testing, and refinement of selected action plans identified in the Phase II efforts. A specific set of recommended,

Table 6. Focus group design.

	State College, PA	Pittsburgh, PA	Lafayette, IN	Austin, TX	Los Angeles, CA
Junior High School Students			■	■	
High School Students		■*		■	■
Parents			■	■**	■*
Junior High School/High School Teachers	■				
Junior High School/High School Counselors					■
College Students	■		■*	■	■**
College Faculty			■		■
Civil Engineers		■			

*AA--African-American
**HA--Hispanic-American

highly selective strategies has been assembled based on the findings of Phase I, the results of the Phase II evaluation procedures described above, and the articulation of the concerns, issues, and suggestions of the project team, consultants, and the NCHRP project panel.

To be effective, the resulting manual must be practical and solution-oriented. Its goal should be to help the user identify and implement alternative actions commensurate with a preselected or intentional strategy. It is envisioned that the action plans considered for further development be of the type that could be packaged to address several target groups. The objective of the final products of Phase III is to permit the user to proceed through a series of logical steps, starting with the identification of an appropriate strategy and increasing in detail through a process of elimination or refinement of candidate actions until a pragmatic package of action items is established. The manual and associated supplemental materials will be field tested to identify the benefits and shortcomings, clarity, and perceived effectiveness prior to final mass production and ultimate distribution.

Chapter **2**

CHANGING DEMOGRAPHICS OF THE POPULATION

GENERAL TRENDS

The predicted changes in the composition of the work force into the next century are documented in several research studies and papers. In 1987, the Hudson Institute published *Workforce 2000* (*2*). This study examined the changes occurring in the economy and in the work force, and projected the jobs this work force will perform between the years 1985 and 2000. Five demographic trends were reported by the study: (1) *The population and work force will grow more slowly than at any time since the 1930's.* (2) *The average age of the population and work force will rise, and the pool of young workers entering the labor market will shrink.* (3) *More women will enter the work force.* The report predicts that approximately two-thirds of the new entrants into the labor force between the years 1985 and 2000 will be women. (4) *Minorities will represent a larger share of new entrants into the labor force.* The report predicts that nonwhites will make up 29 percent of the new entrants into the labor force between the years 1985 and 2000. This percentage is twice the current minority share of the work force. (5) *Immigration will account for the largest share of the increase in the population and the work force since the first World War.* The report predicts that the majority of the new workers entering the labor pool from immigration will be located in the South and West.

The combined effect of these demographic trends is an expected shift in the makeup of the work force between the years 1985 and 2000, as given in Table 7. As Table 7 indicates, women, nonwhites, and immigrants are expected to contribute 85 percent of the net additions to the work force. Currently, these groups constitute approximately one-half of the work force.

The Office of Technology Assessment has reported on two additional demographic trends and their impact on the scientific and engineering work force (*7*). These demographic trends are: (1) the decline in the number of 18- to 24-year-olds (the traditional college-age population) from a peak of 30 million in 1982 to approximately 24 million in 1995, after which this number is expected to rise; (2) the increased representation of ethnic minorities in the 18- to 24-year-old group, from 20 percent to 27 percent in 1998.

The Hudson Institute study predicts not only a change in the supply of new entrants to the work force, but also a change in the demand for skills. Specifically, the new jobs to be created will demand far greater skill levels. More than one-half of the new jobs will require education beyond high school, and approximately one-third of these jobs will be filled by college graduates. Furthermore, the Hudson Institute reports that if occupations are rated and categorized according to skill level (comprising mathematics, language, and reasoning skills), 27 percent of the current (1985) jobs are within the three highest categories. However, the study predicts that 41 percent of the new jobs created by the year 2000 will require a skill level within these three highest skill categories. (Engineering had a skill rating of 5.1. Only the natural sciences (skill rating = 5.7) and law (skill rating = 5.2) were rated higher.)

EFFECTS OF CHANGING DEMOGRAPHICS ON ENGINEERING AND CIVIL ENGINEERING

Historically, the white male has been the principal recipient of the engineering degrees awarded, representing 90 percent of all practicing engineers (*12*). Currently, excluding degrees awarded to foreign nationals, the white male obtains 70 to 75 percent of the degrees awarded annually (*13,14*). Women,

Table 7. Projected labor force trends—year 1985 through year 2000.

Demographic Category	1985 Labor Force	Net New Workers 1985-2000
Total	115,461,000	25,000,000
Resident White Men	47%	15%
Resident White Women	36%	42%
Resident Nonwhite Men	5%	7%
Resident Nonwhite Women	5%	13%
Immigrant Men	4%	13%
Immigrant Women	3%	10%

African-Americans, and Hispanic-Americans are underrepresented groups; that is, their representation in the engineering profession is less than their representation in the general population. Women constitute 47 percent of the population; however, the proportion of undergraduate degrees in engineering awarded to women grew from 1 percent to only 15 percent during the years from 1970 to 1985 (*13*). This percentage has remained relatively constant over the past several years, and is well below the representation of women in the working population. Women earned 15.3 percent of the bachelor of science engineering degrees awarded in 1989 (*15*).

African-Americans and Hispanic-Americans compose 10 percent and 6 percent of the population, respectively, but each group receives only 3 percent of the engineering degrees awarded annually (*14*). Although Asian-Americans are only 2 percent of the working population, the fraction of engineering degrees awarded to Asian-Americans has continued to rise, from 6 percent in 1985 to 8.6 percent in 1988.

For civil engineering, the attainment of degrees by women and ethnic minorities follows the pattern for all engineering degrees. In 1989, women received 13.3 percent, African-Americans received 2.2 percent, Hispanic-Americans received 3.5 percent, and Asian-Americans received 4.5 percent of the civil engineering undergraduate degrees conferred (*1*). Overall, the awarding of bachelor's degrees in civil engineering has fallen from 10,547 in 1981 to 7,688 in 1989 (*1*).

Positions in engineering, and specifically civil engineering, have traditionally been filled by white males. Although improvements have been achieved, women and ethnic minorities remain underrepresented. If demographic trends do not change, only 15 percent of the new workers entering the work force by the year 2000 will be white males. Such a trend could result in shortages in civil engineering.

The Hudson Institute study indicates that the fastest growing jobs in the future are those requiring the highest skill levels. Engineering, as rated by the Hudson Institute, is a profession requiring one of the highest skill levels. However, law and the natural sciences, the two professions rated by the Hudson Institute as having higher skill ratings than engineering, also have higher predicted growth rates than engineering at 71 percent and 68 percent, respectively (*2*). In essence, these high-skill professions (law, science, engineering) will compete for individuals possessing similar skill levels.

Shortages are difficult to predict. Alexander (*16*) has examined previous impending shortages in civil engineering during the 1950's, 1960's, and 1970's. He determined that in each of the periods following the shortage prediction, the average salary for civil engineers decreased relative to the average worker, demonstrating an oversupply, not a shortage. For 1990, the College Placement Council's September *Salary Survey* reports that the average starting salary for civil engineering graduates, both males and females, was the lowest of all engineering specialties (*17*). Another study analyzed the Bureau of Labor Statistics (BLS) predictions made for several engineering occupations in 1960 and 1965 for the years 1975 and 1980 (*18*). The analysis determined that the BLS overestimated, by 20 to 55 percent, the requirements for aeronautical, civil, and mechanical engineers.

A 1986 study of demographic trends and their relationship to the scientific and engineering work force conducted by the Office of Technology Assessment determined that career choices and market forces have a greater impact on the supply of scientists and engineers than population trends (*7*). The study pointed to the difficulty of accurately accomplishing long-term projections and the ability of the labor market to adjust to supply-demand gaps in engineering. The study also noted that companies often respond to short-term shortages through occupational mobility. These companies have changed from the historic "buy" strategy to fill positions to a "make" strategy using systematic training approaches. The OTA study furthermore indicated the need for promoting equality of access in engineering for women and underrepresented ethnic minorities.

In summary, current literature reveals that: (1) The fastest growing sectors of the work force are those sectors requiring the highest skill levels. These sectors include lawyers, natural scientists, and engineers. (2) The white male, who has traditionally filled the engineering and civil engineering ranks, will represent only 15 percent of the new workers entering the work force through the year 2000. (3) Women and the ethnic minority groups, who have continued to be underrepresented in the engineering profession, are expected to represent 62 percent of the net additions to the work force between 1985 and the year 2000. (4) Long-term engineering work force predictions are debatable. (5) Occupational mobility has served to balance short-term labor shortages.

Chapter 3

SUMMARY OF DATA GATHERING—PHASE I

The first phase of the project concentrated on collecting and documenting information on current practices, perceptions, and attitudes in the overall career choice decision-making process. Significant efforts were placed on identifying, synthesizing, and evaluating related literature, products, and programs related to civil engineering, engineering in general, and the mathematics and science disciplines.

Three specific activities were conducted in the Phase I research efforts: (1) Documentation of practices used by undergraduate civil engineering and engineering technology programs and state

transportation agencies to increase interest in civil engineering or civil engineering related careers. (2) Documentation of practices used by other professional disciplines to address their labor shortages. (3) Identification of the attitudes and expectations of various constituencies affecting civil engineering career-choice decisions (via intensive "focus" group interviews).

A summary of the documentation of selective and related practices and programs is provided in this chapter. The discussion of the findings of the focus group sessions regarding career-choice decisions follows in Chapter 4. Part II of this report contains additional detail on each practice or program identified in the data gathering process. The appendixes serve as a *cataloged reference* to national practices, programs, and examples of the efforts of state highway and transportation agencies; departments of civil engineering and civil engineering technology; educational institutions; other professional, resource, governmental, and industrial organizations; and other engineering and science disciplines.

Particular attention and emphasis were placed on the implications of the changing demographics in the U.S. work force throughout the data gathering phase. Each inquiry attempted to identify specific considerations being given to underrepresented groups. One common assessment among the numerous sources was a fundamental need to heighten the awareness of the public to the attributes of the civil engineering profession. Efforts to better inform prospective students and their parents, teachers, and counselors are seen as having the broader benefit of educating the public regarding the role of the civil engineer in society.

PRACTICES TO INCREASE INTEREST IN CIVIL ENGINEERING

Federal and State Transportation Agencies

The information received indicated that the practices could be categorized into three general classifications: career information programs, preemployment programs, and post-employment programs.

The career information programs include primarily videotape and printed materials, career day participation, open house activities conducted by the transportation agency, encouragement of role models and mentors, support and sponsorship of science fairs, participation in professional organization activities, and occasional teacher internship programs.

The preemployment programs are most often directed toward college students already enrolled in civil engineering and engineering technology programs. The involvement typically includes cooperative education opportunities, financial support in the form of scholarships, and summer employment opportunities for students entering their junior or senior year.

The post-employment programs focus on continuing education and career guidance activities that influence both recruitment and retention. Such programs generally include engineer-in-training efforts, tuition reimbursement to encourage continued education, career counseling regarding future opportunities or alternative career paths, mentor programs, and advanced degree programs.

The majority of the respondents indicate that videotapes, printed materials, and career day participation are predominant activities to disseminate career information regarding the transportation agency. Summer employment and cooperative education programs were noted by the majority of the respondents. Post-employment development programs focus primarily on preparing the engineer via on-the-job training activities and mentoring programs. Tuition reimbursement and in-house training and development programs are occasionally provided.

Several initiatives were identified to increase interest in civil engineering with an emphasis on the participation of minorities and women. On-the-job training, minority engineering scholarships, and summer intern programs are representative of transportation agency programs. Several state transportation agencies reported the use of "adopt-a-school" programs to encourage employees to volunteer their services for mentoring, speaking, guidance, and judging at science fair activities. The Transportation and Civil Engineering (TRAC) careers center concept would strengthen the existing initiatives used by the various states (*19*). The TRAC program would provide quality information that could be readily implemented through the programs already identified. Such a national outreach program would permit the state agencies to utilize their time disseminating consistent, reliable, and effective materials rather than using their resources to produce new material.

Efforts by the Federal Highway Administration (FHWA) are generally similar to those of each state agency; for example, internship programs, programs targeting women and minority students, summer intern programs, and grants for research fellowships.

Departments of Civil Engineering and Engineering Technology

The survey revealed that few civil engineering and engineering technology departments are active in recruiting students in civil engineering. The responses indicated that the college of engineering or the entire educational institution generally provides pre-college career information and undergraduate information.

The pre-college programs typically include videotapes or printed information, attendance at various high school open house activities, participation in science fair activities, and involvement with summer workshop programs. Undergraduate information programs are primarily accomplished through student chapters of professional society organizations in addition to the techniques identified above.

The few civil engineering departments that reportedly are active in recruitment activities identified some of the following specific efforts: follow-up letters to information pamphlets, identification of the top-ranked students on the standard ACT and SAT exams, identification of potential students via the Educational Testing Service search, receptions and conducted tours of the civil engineering departments, encouragement of freshman engineering students to attend student chapter professional activities, and encouragement of "hands-on" experience via technical workshop programs. Some civil engineering departments indicated participation in activities to promote the importance of math and science to junior and senior high school students.

Institutional Efforts

Institutions of higher education identify their efforts of recruitment as either pre-college programs or undergraduate programs.

"Intervention programs" differ from traditional educational efforts. These programs include academic program enrichment efforts (some are pre-college, academic school year pre-college, Saturday morning activities, and student outreach programs aimed at enriching the science experience); instructional applications (linking math and science course content); student internship and research projects (the selective involvement of pre-college students in ongoing research efforts); academic advising and counseling; and traditional science fairs and industry field trips. Additionally, programs identified as "long-term personalized intervention programs" heighten the awareness and opportunities for the students (from elementary through high school). "In-service training programs" for teachers and counselors were also identified as stimulating learning and promotion of mathematics and science areas.

Higher education institutions, as well as the colleges of engineering, provide very little information that promotes civil engineering via the overall institution. One academic institution that is actively promoting civil engineering is the New Jersey Institute of Technology through its Center for Pre-College Programs. The program emphasizes the importance of a "math/science" sequence and recognizes that many minorities and women are unfamiliar with the role of civil engineering in urban life. Thus, through a focus on urban engineering, the civil engineering profession is introduced. The topics that are covered include urban planning, transportation engineering, energy systems, and environmental science.

Transfer programs, from both engineering and engineering technology, concentrate on articulation agreements between participating institutions. As such, the curriculum transition is being addressed for those students that have already identified civil engineering as their intended career path.

Closely aligned with transfer-type programs is the broad spectrum of opportunities that are available to students desiring a career in the engineering area. The breadth of the engineering career extends from the craftsman through the engineering technician, the engineering technologist, and the professional engineer. Many educational institutions are developing programs to attract specific students to particular programs, while taking special care to clearly describe the boundaries and constraints of each engineering-related profession. An important note is that institutions indicate that many former students continue their education and advance through the entire engineering team ladder.

Minority engineering programs accomplish their objectives through formal orientation programs; the addition of appropriate academic support, including tutorial services; and emphasis on preparation in mathematics and science areas. Such programs also facilitate the personal and professional growth of the minority engineering student.

Similarly, the women-in-engineering programs offer a comprehensive approach focusing on recruitment, retention, and relations with industry and alumni.

Nationwide, institutional efforts are increasing regarding effective freshman orientation programs and the promotion of mathematics and science to all incoming students.

Professional and Industrial Organizations

American Society of Civil Engineers. The career guidance activities of ASCE range from encouraging strong elementary school programs in mathematics and science, to encouraging practicing engineers to continue their education. The committee structure of ASCE provides career guidance information in the forms of printed material and audiovisual presentations. Likewise, student service committees help students prepare for the engineering profession and stimulate interest in engineering practice among undergraduate students. Other professional activity committees focus on minority programs for kindergarten through 6th grade, junior high school, and high school students. Many local sections and branches have outreach programs and contact members designated to work and assist at high school level programs. Workshops and other technical activity committees have recently focused on attracting students towards particular civil engineering specialties.

In 1990, ASCE had a marketing plan prepared for career guidance. The marketing plan provides information regarding the development and implementation of an educational career guidance campaign. The plan includes specific strategies for attracting young people to civil engineering, with an emphasis on women and minority students. The recommended action plan for ASCE includes: (1) development of programs at the branch and section levels of ASCE to promote science and mathematics at all grade levels; (2) promotion of interest in civil engineering by involving the ASCE membership in in-class presentations and demonstrations; (3) encouragement and education of high school science and mathematics teachers through involvement in science fairs and mathematics competitions and by providing information regarding the benefits and rewards of a civil engineering career; (4) provision of tours of construction sites and related civil engineering facilities; (5) continuation and expansion of advertising initiatives at the national level to increase the awareness of civil engineering; (6) coordination of ASCE activities with other efforts to promote and expand science and mathematics awareness; (7) increased participation and encouragement of underrepresented groups to pursue the civil engineering career; (8) encouragement of undergraduate degree holders to pursue graduate study and consider faculty careers.

Institute of Transportation Engineers. The Institute of Transportation Engineers has also been active in recruiting and retaining civil engineering students in the traffic and transportation engineering discipline. Their activities include fellowship programs, support of student chapter activities, committee activities, investigation of professional career opportunities in transportation engineering, and preparation of informational materials in the form of printed material and videotape.

PRACTICES TO INCREASE INTEREST IN ENGINEERING, MATHEMATICS, AND SCIENCE

Professional, Resource, Governmental, and Industrial Organizations

Although the focus of the research was aimed at the civil engineer, numerous programs already exist that serve to stimulate an individual's interest in a technical career. Therefore, practices, programs, and literature related to increasing one's interest in engineering and mathematics and science were sought, reviewed, and documented. The salient attributes have been identified to aid in the development and implementation of a comprehensive effort to increase the civil engineering pool.

Professional Organizations

National Society of Professional Engineers. The National Society of Professional Engineers is involved in numerous activities promoting engineering and technical careers. The NSPE Education Foundation's Pre-College Career Guidance Committee has developed activities that include the following: (1) creation of an engineering guidance brochure for junior and senior high school students; (2) production of a videotape that relates mathematics, science, and engineering to bicycle design; (3) development of the Engineering Explorer Post of the Boy Scouts of America; (4) establishment of the National Engineering Design Challenges, designed for grades 9 through 12, to solve nonroutine societal problems; (5) Project XL, which involves the promotion of creative thinking and problem solving in primary and secondary schools; (6) generation of awareness programs among educators, parents, businesses, governmental agencies, educational associations, and professional societies; (7) implementation of a career volunteer network of programs; (8) provision of scholarships totaling more than $1 million in grants and awards to students; (9) planning of programs for 5th to 8th grade teachers and also an instructional package available for classroom use designed for grades 4 through 6, which will provide activities and resource information on engineering.

The committee has also been responsible for "National Engineers Week," a long-established career guidance activity. During the 1990 National Engineers Week, a new program, Discover "E," was introduced as an outreach program coordinated by several engineering professions. NSPE has also been involved in the development of the first nationwide program to promote math excellence for junior high school students (MathCounts).

In 1986, NSPE performed a study titled "Career Guidance in Engineering." This study reviewed the career decision-making process of individual students and identified factors that influence that decision making. Their findings indicated that no single method of obtaining career information is completely effective by itself. Personal contact, in combination with written and audiovisual material, was considered ideal.

The Engineering Society for Mobility, Land, Sea, Air, and Space (SAE International). SAE International has a strong capability of attracting young people because of the excitement that comes with careers related to mobility. SAE's programs such as "Vision 2000" have reached all educational levels from elementary through graduate school. A multifaceted educational program titled "A World in Motion," developed for SAE, has been designed to improve the science and mathematics education of 4th- to 6th-grade students and encourage them to consider careers in the mobility engineering area. The educational program has integrated print and videotape materials and emphasizes hands-on discovery of science principles through cooperative and interactive activities. The program emphasizes interactive learning by helping students understand abstract, scientific, and mathematical concepts through a process of exploring, discovering, investigating, and applying the concepts. SAE members are encouraged to participate actively in order to implement the program fully.

American Society for Engineering Education. ASEE coordinates a summer program, "Washington Internships for Students of Engineering (WISE)," for third-year engineering students. Approximately 16 engineering students are chosen each summer who are outstanding scholars representing a broad spectrum of engineering disciplines and universities. The principal objectives of WISE are to increase the understanding of policy issues for future engineers, to sensitize engineers to public policy issues, to enhance the image of the engineering profession, and to support policy activities of the various societies.

Unfortunately, the WISE program has not had comparable success in appealing to minorities.

American Consulting Engineers Council. ACEC sponsors the program Students Engaged in Engineering (SEE). This program is currently in operation in two locations. The intent is to expand this outreach program to all 50 States. The resource materials available to promote the SEE program include a handbook, an easy-to-read pamphlet, and a newsletter.

American Association of Engineering Societies. AAES is involved in the establishment of the engineering societies task force on pre-college mathematics and science education. This activity is intended to link each school in the country with an engineer who can provide assistance and supplementary materials to mathematics and science teachers.

Four professional engineering societies (ASME, SMME, IIE, and IEEE) provided information regarding their programs and activities to promote their particular disciplines. The reported programs and activities are similar in nature to the current efforts to promote civil engineering. In addition to the brochures, booklets, posters, and pre-college activities, the following findings were different from the civil engineering related activities.

ASME targets students, particularly in grades 6 through 12, and has videotapes targeting grades 6 through 9, and a videotape targeting young women and minorities in grades 8 and 9 by describing the contributions of women and minorities to the engineering profession. Also, some of the ASME materials discuss the difference between mechanical engineering and mechanical engineering technology.

American Chemical Society. The ACS Education Division program activities include the following: (1) Project Seed — directed at economically disadvantaged high school students; (2) Pre-high school science — produces *Wonder Science* magazine for grades 4 through 6; (3) Chemistry walks — posters for display in elementary school classrooms; (4) "Chemist in the Classroom" videotape — designed to assist academic and industrial chemists who volunteer to work in elementary school classrooms as teacher-resources; (5) "Working It Out" — a videotape designed to promote science education to high school students.

Resource Organizations

National Action Council for Minorities in Engineering. NACME is dedicated to increasing the number of African-Americans, Hispanic-Americans, and Native-Americans who enter the engineering profession. NACME supports its efforts by providing scholarships, grants, and pre-college and university intervention programs, and by creating and disseminating materials that promote interest in engineering careers. NACME has also published a guide to pre-college minority programs and a publication that provides an overview of the issues and concerns facing engineering students.

Society of Women Engineers. SWE administers more than 40 scholarship programs and provides publication information for women engineers.

Math/Science Network. The Math/Science Network conducts programs to promote the participation of young girls and women in mathematics, science, and engineering. These activities include conferences, videotapes, maintenance of a database on women's study programs, and a resource center containing a collection of science and mathematics materials.

Society of Hispanic Professional Engineers. SHPE has developed retention programs at the university and college level to assist students completing their engineering degree program. The society aims to retain students' interest in technical programs from elementary through university-level programs.

American Indian Science Engineering Society. AISES seeks to significantly increase the number of Native American scientists and engineers in the United States and to develop a more technologically informed leadership within the Native American community. AISES activities include a mathematics and science enrichment summer camp, high school mathematics enrichment programs, teacher training programs, and written publication materials.

Texas Alliance for Minorities in Engineering. TAME was founded by Texas industrialists and educators to promote minority student interest in the engineering profession. Each local chapter utilizes the resources of local industries, universities, and public schools in its outreach program.

Southeastern Consortium for Minorities in Engineering. SECME operates within the educational structure at the junior and senior high school levels. SECME's activities include: (1) identification and placement of minority students with academic potential in college preparatory courses; (2) enrichment of college preparatory courses with supplemental mathematics, science, and language arts curriculum materials; (3) development of guidance information to heighten the awareness of opportunities in engineering, mathematics, and science-based fields; (4) service as role models to demonstrate the benefits of careers in the technical areas.

Junior Engineering Technical Society. JETS is a pre-college association for students interested in engineering, technology, mathematics, and science. Activities include tests of Engineering Aptitude, Mathematics, and Science (TEAMS); the National Engineering Aptitude Search (NEAS); coordination of the Minority Introduction to Engineering (MITE) Program; and provision of engineering design contests and guidance publications.

National Association of Pre-College Directors. NAPD directs its efforts at increasing the pool of students who pursue engineering and mathematics-based college study. Students who participate in NAPD programs are from ethnic groups that are historically underrepresented in the science and engineering professions. Most of the programs that were identified earlier as intervention-type activities are typical of the NAPD program.

National and Governmental Organizations

National Governors' Association. NGA has examined the pre-college and undergraduate intervention programs currently in existence and the efforts presently being made by states to increase the participation of women and minorities in engineering.

National Science Foundation. NSF has numerous programs designed to enhance engineering education as well as secondary school preparation of future scientists and engineers. Two of the more pertinent programs are: (1) the Career Access Opportunities in Science and Technology for Women, Minorities, and the Disabled Program — intended to develop a systematic approach to increasing minority presence in science and engineering through total partnership among universities, local school systems, and government and industry; and (2) the Engineering Education Coalition Program — supports the design, development, and testing of innovative approaches for increasing the effectiveness of the undergraduate engineering learning experience.

U.S. Department of Energy. The DOE is currently providing funding for several initiatives to promote the study of mathematics and science. These include: (1) "The Explorers Program" — promoting mathematics and science at the secondary school level; (2) development of a 5-year coordinated curriculum at a state college and a university; (3) sponsorship of summer internship programs for students studying mathematics and science as future teachers.

National Aeronautics and Space Administration. NASA also supports several endeavors to promote interest in mathematics, science, and engineering. Such programs include recruitment and retention efforts for freshman engineering students, a summer high school apprenticeship program, and a congressionally approved National Space Grant College and Fellowship Program. The purposes of these programs are to encourage careers in aeronautics, space technology, and other related fields.

Sample Industrial Organizations

Westinghouse Corporation. Through the Westinghouse Foundation, the Westinghouse Corporation makes charitable contributions to higher education with areas of primary interest in engineering, applied science, and business disciplines. Special attention is given for minority communications that focus on communicating to minority youth an awareness of career opportunities in engineering, science, and technology. Several of the Westinghouse Foundation advertising campaigns have won awards for successfully communicating the career opportunities to young adults. In additional program areas, Westinghouse assists in a Head Start Program where students learn hands-on scientific investigation and participate in seminars, field trips, and workshops. The Westinghouse Foundation also participates in the Women in Engineering Initiative (WEI), providing tutoring, mentoring, and counseling.

Rockwell International. Concerned with deficient student performance in mathematics and the sciences, Rockwell responded to the situation by supporting more than 200 programs aimed at students from kindergarten through the university graduate level. Rockwell's activities have included teacher grant programs, special mathematics and science teaching delivery systems, teacher internships at Rockwell facilities, curriculum development advisors for elementary and secondary education (especially in the areas of mathematics and science), resources and support for teachers in the application of mathematics and science to industry needs, mathematics and science student competition programs, student intern program, and programs of intensive remedial teaching to at-risk students.

Rockwell calls upon volunteer efforts of its employees and retirees in helping in the various programs. Rockwell has also launched a multimedia advertising campaign to encourage individuals in companies to support schools in their communities.

Sample Metropolitan Partnership Programs

Adequate financial and personnel resources are necessary to achieve the goals of increased educational activities. Two model intervention programs follow that have been based on an educational partnership commitment.

Philadelphia Regional Introduction for Minorities in Engineering. Founded in 1973, PRIME is a pre-college partnership of Philadelphia-area businesses, governmental agencies, colleges and universities, professional associations, and parent groups. The goal is to identify and prepare minorities for careers in technical and scientific professions. Among the noteworthy PRIME activities are development of industry-supported pre-college programs, focus on efforts to increase the number of minority students entering and completing technical-college degree programs, and week-long summer institutes designed to update teachers' skills and to illustrate mathematics and science applications.

Chicago Careers For Youth. The career guidance program of the Chicago Careers For Youth (CCFY) is another example of the educational partnership process. In this program, role models in the business world interact directly with students in grades 6 through 12. The role-model speakers bring their personalities, videotapes, booklets, and other pre-prepared discussion materials. Students are exposed to 16 different clusters of material, including the areas of civil and environmental engineering, transportation, agriculture, and education.

PRACTICES USED BY OTHER PROFESSIONALS

Agriculture Related

The number of baccalaureate degrees awarded annually in agricultural engineering has dropped by 50 percent over the past decade. Thus, aggressive recruiting of students by individual academic departments has become necessary. The activities involve immediate response to student inquiries; qualified public information for use in recruiting materials, with material that emphasizes the diversity of the career opportunities; and efforts through the agricultural extension service to reach the local public.

Health Care Industry

The health care industry is expected to experience a 50 percent rate of growth between the year 1985 and the year 2000. Among the noted techniques to increase new entrants to the health care profession are summer enrichment programs designed for freshman and sophomore students, retention programs to smooth the transition from undergraduate school to professional school (2 to 10 weeks in length), and major U.S. Department of Health and Human Services funding for recruitment and retention programs for targeted and disadvantaged individuals.

The nursing profession is expected to have one-half as many nurses with baccalaureate degrees as needed nationwide by the year 2000. Ironically, some of the problems associated with the nursing shortage are created by the transition of the traditional pool of potential nurses who pursue medicine, law, and engineering. Studies to alleviate the nursing shortage have found the need to conduct public relations campaigns to overcome negative images of nursing and specifically to improve the image conveyed to the *underrepresented male.* Radio and television campaigns are currently being conducted as outreach programs. Further, the Robert Wood Johnson Foundation and The Pew Charitable Trusts are sponsoring a 5-year, $26.8 million program to find innovative solutions to the Nation's shortage of nurses.

Governmental Organizations

The public's view of the military has improved in recent years, which has made military recruitment somewhat easier. The Reserve Officer's Training Corps program still identifies recruiting as a particularly tough assignment. The findings simply indicate that every method of public information and advertising has been used to heighten the awareness and provide guidance material by way of marketing consultants in order to achieve an effective recruitment effort.

Responding to the dramatic growth predicted in the aviation industry through the end of the century, the Federal Aviation Administration has initiated a program that is an educational partnership between the FAA and the academic community at the undergraduate level. The role of the FAA in this program includes curriculum development, appropriations to participating higher education institutions to help implement the program, and employment of a number of the qualified graduates each year.

Chapter **4**

CAREER CHOICE DECISIONS

As cited in the previous chapter, a third task in the data gathering process was the conduct of focus group sessions to determine the attitudes and expectations of students, teachers, and guidance counselors; the degree of awareness of civil engineering as a discipline and career alternative, and the perception of what a civil engineer does. A summary of the key findings of a selective literature review and the major results of the focus group sessions are presented in this chapter. Appendix F contains a complete copy of the Brand Consulting Group report on the focus group sessions.

LITERATURE FINDINGS

The literature review resulted in the following key considerations. These findings were used in the development of the focus group protocols for the market research study:

1. *Interest in the field*—The individual's interest in the field, as characterized by the perception that the field involves interesting work with a variety of responsibilities, appears to be a primary influence in the career choice decision.
2. *Parents, teachers, and counselors*—Each of these key groups plays an important role in encouraging young people to pursue engineering. The influence of the teachers and counselors may be more important for the minority population.
3. *Minority students*—For minority students, financial resources, lack of early educational opportunities, and concern with future opportunities are primary factors affecting the career choice decision.
4. *Women*—For women, female socialization patterns and concerns with future opportunities are primary factors affecting the career choice decision.
5. *Role models*—Role models continue to be an important motivational factor.
6. *Image*—The image of the engineering profession—and specifically the civil engineering profession—is poorly defined, among both prospective students and their adult advisors (parents, teachers, counselors).

MARKET RESEARCH STUDY

The focus group activities proved to be a highly effective means of data collection, in that they produced observations that are difficult to capture through questionnaires or other quantitative methods. The information provided in this report is based on the results of 17 intensive group sessions.

Attitudes toward mathematics and science include the following: (1) the teacher emerged as most directly affecting subject preferences; (2) teachers' enthusiasm and qualification motivate the student; (3) mathematics classes, at all levels, pay very little attention to practical applications; (4) teachers would use materials featuring technical applications if they were prepackaged and integrated into the existing curriculum; (5) parents want their children to do well in *all* classes (many parents do not feel qualified to help their children in mathematics and science); (6) secondary school guidance counselors do not seem to greatly influence student attitudes toward mathematics and science.

With respect to *career planning,* it was found that elementary school students are stimulated more by outside influences than by what specifically happens at school; and students and parents both indicate that junior high school is too early for specific career planning, but definitely appropriate for career awareness.

In high school, there is increased recognition that career options must be seriously considered. Students and parents seek specific information regarding career salaries, work hours, work routines, advancement potential, and education requirements. Students responded with mixed enthusiasm regarding programs specifically oriented toward career awareness.

Summer programs and other types of enrichment experiences (exposing target groups to technical careers) are the exception. Such programs are received enthusiastically and are considered highly successful.

There is little or no exposure to career-related material in the classroom. Teachers are interested in using such materials, but these materials can potentially overcrowd a curriculum, so using them effectively requires great motivation and dedication on the part of the teacher.

Students who do well in mathematics and science are attracted or directed toward careers in engineering.

Attitudes toward careers include the following: (1) Students (and virtually everyone else) have very little information about specific careers. This is especially true of engineering and particularly true regarding civil engineering. The term "civil engineering" means almost nothing to those who are uninformed. The image of the civil engineer is related typically to road construction or maintenance, or working for local government at a low salary. (2) Individuals relate better to career terms such as transportation engineering, structural engineering, construction, and environmental engineering. (3) Individuals indicated that the civil engineering field would not be challenging, because most techniques for building roads and bridges are well know. (Similar misconceptions were noted for other civil engineering specialty areas.) (4) Professional licensing tended to confer distinction upon the civil engineering field as a career choice.

Attitudes of women and minorities: (1) There seemed to be no markedly different reactions to the civil engineering profession in comparison to the other groups already identified. (The prescreening of group participants, described in Part II of this report, emphasized quantitatively oriented college-bound students, which is a major factor in interpreting this and all results relating to women and minorities.) (2) Minority students reported favorable reaction to mathematics, science, and engineering enrichment programs. (3) College-bound minority students recognize the need for financial aid and are highly motivated to seek and qualify for such aid. The remuneration potential among engineering careers was of relatively greater concern to minority students, although this seems to be related more to economic status than to ethnicity. (4) Parents appeared somewhat troubled by recruiting efforts directed toward their children; several cautioned against painting a false picture of the relative desirability of engineering or civil engineering careers. (5) Students as role models were mentioned often, and with greater emphasis by the minority group members. (6) College students were mentioned as good role models for communicating with secondary school students. (7) There is still a chilly climate for women and minorities in the workplace, which is of concern to women and minority engineering students. There is also lingering discrimination in the classroom, especially by older males and foreign-born faculty toward women students. (8) Many women and minority group members felt that they would have to start their own firms to get around a "glass ceiling" that blocks their advancement in larger organizations. (9) Civil engineering was noted as a field where entrepreneurship is highly possible, but few students are aware of this.

Chapter **5**

RECOMMENDED PLAN OF IMPLEMENTABLE ACTIONS—PHASE II

The findings from the data gathering process conducted in Phase I and the results of the 2½-day workshop were compiled and evaluated by the project team. A synthesis of the Phase I efforts resulted in the identification of several fundamental obstacles facing the civil engineering pipeline: (1) an image problem that exists for the civil engineering profession; (2) institutional barriers that contribute to the increasing attrition rates among high school and college students; and (3) changes needed in pre-college and college curricula if enhancements are to be made in mitigating items 1 and 2.

THE ARC MODEL

To effectively address these obstacles, the research effort has developed a conceptual framework consisting of three interrelated long-range market strategies: (1) Heighten the **AWARENESS** of technology, engineering, and civil engineering. (2) Increase the **RETENTION** of the existing pool of future civil engineers. (3) Modify the existing **CURRICULUM** from kindergarten through college.

These key strategies serve as the focus for an overall marketing effort that recognizes the developmental stages of the pool of potential engineers. Figure 2 illustrates the primary components of the recommended conceptual framework, which is referred to as the "ARC" (*A*wareness, *R*etention, *C*urriculum) model. The target audiences for the candidate action plans include students and their adult influencers (teachers, counselors, parents, and practicing professionals).

The ARC model has the following characteristics: (1) It is a continuum model that builds upon previous experiences. (2) The action plans, though not independent of each other, are implemented differently at each developmental stage. (3) To achieve a long-term effectiveness, the model as a whole must be implemented. (4) The action plans for the three strategies are broad at the early developmental stages and narrow to more specific actions as higher developmental stages are reached. (5) Overlap and crossover benefits occur between the three strategies.

Heightening Awareness

Images are recruiting mechanisms. The market research shows that civil engineering has a poorly defined image among students (the pipeline) and their adult advisors (influencers). Image responses that are nonexistent, unflattering, or inaccurate are reasons for dismay. Furthermore, engineering, in general, was seriously misunderstood. A large number of engineering students in the market research sessions stated they had no comprehension of the engineering profession when they entered engineering school.

Accurate, timely, and relevant information must be provided to the pipeline and its influencers. Answers to the following questions must be addressed in the proposed action plans: Why are mathematics, science, and engineering important to the future? How do civil engineering and its specialties impact society? What does a career in civil engineering offer (in terms of compensation, working and employment conditions, opportunity for advancement)? How does one obtain additional information on civil engineering and its specialties? What educational preparation is required? What intervention programs are available to provide assistance in the career choice decision?

Increasing Retention

It should be viewed that every student entering kindergarten is already a member of the civil engineering pool; each is also a member of every other potential career pool. The trend has been such that progressively fewer students choose and retain civil engineering as a profession. Specifically, ethnic minorities and women remain greatly underrepresented in selecting engineering and civil engineering for study. When compared to the retention rates for the traditional pipeline member (the white male), the retention of ethnic minorities and women in civil engineering programs is low.

Retention efforts are necessary at both the pre-college and undergraduate levels. Additionally, these retention efforts must also be of a more personal nature (i.e., intervention) as compared to the awareness strategy.

To retain pre-college students in the civil engineering pipeline, emphasis must be directed toward: (1) building positive attitudes and self-confidence in *mathematics* and *science;* (2) helping students understand the consequences of curriculum and course choices, so that later options will not be prematurely closed; (3) developing civil engineering guidance programs that give students an awareness of opportunities in civil engineering and assist them in making a career choice; (4) providing quality, professional presentations and field trips to increase and retain students' *interest;* (5) providing appropriate role model and mentor opportunities; and (6) supporting and encouraging students to involve themselves in existing *intervention* programs.

Retaining undergraduate students in civil engineering requires efforts from both the college of engineering and the department of civil engineering. Such retention efforts should include: (1) building the students into a supportive academic *community;* (2) delivering appropriate *academic support;* (3) developing student

Market Strategies	DEVELOPMENTAL STAGES				
	Pre-College (grade level)			College (year of study)	
	K-6	7-8-9	10-11-12	1-2	3-4
AWARENESS	The Environment →	The Engineer →	The Civil Engineer	Introduction to Civil Engineering Disciplines →	Summer/ Co-op Employment
RETENTION	Field Trips →	Role Models →	Peer Mentors	Clustering →	Professional Mentors
CURRICULUM	Technology Applications →	Mathematics and Science Emphasis		Introduction to Design →	Project Design

Figure 2. ARC model.

peer network relationships and making use of faculty mentoring; (4) strengthening the commitment to the *value* of higher education; (5) improving the academic and study skills of the students; and (6) explaining the relationship between *academic preparation* and *chosen career.*

In addition to the foregoing efforts, the civil engineering profession, in conjunction with the departments of civil engineering, should: (1) provide meaningful cooperative education opportunities; (2) provide meaningful summer employment opportunities; and (3) support efforts to provide appropriate role model and mentoring opportunities.

Modifying Curriculum

Civil engineering lacks image or, in other words, personality. Students, especially pre-college, fail to grasp the relevancy of their mathematics and science courses. Yet, the importance of the teacher as an influencer cannot be understated. Drawing on these observations, the third market strategy, curriculum modifications, through the pre-college and college experience, is warranted. This is a long-term process that will require the cooperative efforts of engineers, educators, administrators, school boards, parents, counselors, and curriculum developers.

The curriculum at the pre-college stage can be modified through: (1) development of a more creative and cohesive mathematics and science curriculum that integrates the relevancy of the subject material; (2) development of curriculum materials that illustrate how mathematics and science integrate with social concerns in solving civil engineering related problems; and (3) incorporation of the importance of mathematics and science preparedness.

The curriculum at the college stage can be modified through: (1) provision of *early exposure* to the engineering profession and its specialties; provision of *early and intensive exposure* to the civil engineering profession and its specialties; (3) emphasis on strong preparation in oral and written communication skills; and (4) emphasis on the important connection between technical and social science and humanities courses.

THE DEVELOPMENTAL STAGES

The market research revealed that parents and students believe that junior high school is too early for selection of a specific career. However, senior high school is the appropriate stage for serious career exploration. Actions to implement the ARC strategies must therefore vary with respect to the developmental stage of the target audience. The pre-college actions were divided according to grade levels of kindergarten through 6th grade; 7th, 8th, and 9th grades; and 10th, 11th, and 12th grades. At the undergraduate level, these actions were subdivided into initiatives of the college of engineering and department of civil engineering activities.

The attributes of the various developmental stages are briefly discussed next.

The Early Years

It is widely acknowledged that children begin to formulate career decisions at a relatively young age. They acquire impressions of the work people do, the kind of people employed in various occupations, the compensations offered, and the abilities required for acceptable performance. On the basis of these impressions, they enthusiastically embrace some occupations as possible careers for themselves and absolutely remove others from either present or future consideration. Accordingly, presenting children (along with parents, teachers, counselors) with positive images and impressions about general (i.e., global) engineering may begin at the elementary level. Capturing their awareness of how engineering relates to the needs and functions of society (early relevancy), of the interrelationship of work and learning, and of the importance of educational achievement to opportunities in an engineering career (along with building confidence) are among the first steps toward increasing civil engineering awareness.

Junior High

This level is a transition period between general and specialized education. Exploration and planning are important for students (and parents) at this level. Timely, relevant, and accurate information about engineering with an introduction to civil engineering may be introduced at this time. Through this awareness and exploration of engineering, answers can be offered regarding: (1) the amount and type of education needed for entrance; (2) the content, tools, settings, products, or services with which engineering is associated; (3) the potential of such an occupation to satisfy personal interests; and (4) the potential of such an occupation to provide the type of lifestyle desired. With such answers, planning (and relevant course choices) for the next educational level will start at the appropriate time. Keeping in mind the continuing need to instill confidence and the relevancy of mathematics and science is essential.

Senior High

Providing students (and parents) with specific career information regarding civil engineering and its specialties continues through the senior high school level. It is at this stage where career choice, real or perceived, takes place. Technical interest must be maintained. Preparatory classes to pursue undergraduate work must be completed. Role model and mentoring activities, coupled with summer employment opportunities, workshops, use of information systems, and participation in intervention programs contribute to the retention of the student's interest.

The three market strategies of the ARC model cannot stop upon entrance to a university. Engineering freshmen with undecided majors, students in other scientific colleges, and students in junior college and vocational-technical schools, could be motivated into civil engineering *if made aware of civil engineering.* Junior college and vocational-technical students are individuals that traditionally have not entered the civil engineering pipeline. Returning adults is another group to be considered. It should also be recognized that many of the students' decisions at the undergraduate level may well be short-term compromises. As such, the importance of continual professional development must therefore be instilled in the graduate.

Market Strategies	Pre-College			University	
	Elementary (Grades K-6)	Junior High (Grades 7-8-9)	Senior High (Grades 10-11-12)	Engineering/Non-Engineering Students (Freshman/Sophomore)	Civil Engineering Students (Junior/Senior)
AWARENESS	ARC-1 Discuss technology and global engineering.	ARC-4 Present engineering as a career alternative with an introduction to civil engineering.	ARC-7 Provide civil engineering career information.	ARC-10 Provide engineering career information to: • Civil engineering students • Students in other majors • Students at other institutions	ARC-13 Provide information regarding the disciplines within civil engineering.
RETENTION	ARC-2 Build confidence in mathematics and science.	ARC-5 Maintain confidence in mathematics and science.	ARC-8 Promote and retain technical interest.	ARC-11 Retain and graduate civil engineering students.	ARC-14 Retain and graduate engineering students.
CURRICULUM	ARC-3 Integrate early relevancy of mathematics and science.	ARC-6 Encourage further pursuit of mathematics and science.	ARC-9 Complete mathematics and science requirements.	ARC-12 Integrate early exposure to engineering/civil engineering disciplines.	ARC-15 Integrate design projects (collaborative learning) into the curriculum.

Figure 3. Goals of the candidate action plans.

RECOMMENDED ACTION PLANS

The ARC model argues that to successfully enhance the civil engineering pipeline, future marketing strategies must consider *awareness, retention,* and *curriculum* issues in the development of individual action plans. Specific objectives must likewise be defined at each developmental stage of the model for the pipeline constituents.

As one proceeds through the developmental stages, a selected objective becomes more narrowly defined (from global engineering to civil engineering to the specialties of civil engineering). Similarly, as one proceeds from the awareness strategy to the retention strategy to the curriculum strategy, the target audience also narrows.

Awareness strategies target both the potential pool and the influencers (parents, teachers, counselors, and practicing professionals). The retention strategies tend to be more personalized. Curriculum strategies intimately affect the students (and teachers).

Fifteen candidate action plans were developed to essentially address specific issues at each defined developmental stage. The goal of each recommended action plan is cited in Figure 3. If the ARC model were fully implemented, the awareness, retention, and curriculum strategies applied at the pre-college developmental stages should reduce the need for the college actions.

Appendix G contains the individual action plans recommended for further development in Phase III of NCHRP Project 20-24(3). Each action plan is organized in a four-page format. The goal, specific objectives, and target audience of the candidate action plan are presented on the first page. The target audience may include the pipeline constituents or their influencers, as appropriate. The elements of the plan, both essential and supportive, are presented on the second page. The third page of the plan describes the implementation issues, including a description of the implementation activities, the resources required, and suggested responsible parties. Finally, each action plan concludes on a fourth page that provides a justification statement based on the findings of the data collection (Phase I) and market research (Phase II). Related activities being performed by other engineering disciplines or other professions are also highlighted for each action plan.

Chapter **6**

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The research completed in this project leads to eight principal conclusions, which are summarized and briefly explained as follows:

1. **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 recruiting, 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.

2. **Additional efforts to enhance the civil engineering pool are warranted.** Although there are mixed opinions within the profession about the reality of forecasts of a future shortage of civil engineers, there is general agreement that women and ethnic minorities are very much underrepresented in the field, and that the academic preparation of today's generation of students is lacking. Further, the demographic trends presented in Chapter 2 are undeniable; even if civil engineering continues to attract the present percentage of white male college students, the future number of annual new civil engineering graduates will plummet. Thus, action is warranted both to maintain sufficient interest among the traditional pool of entrants and to enhance the quality and diversity of the pool of future civil engineers. Taking actions that are motivated by recruiting concerns will have the added benefit of better informing the public about civil engineering and developing a favorable image of the profession.

3. **Enhancement efforts should go forward as a coordinated program with the three themes of Awareness, Retention, and Curriculum.** The *A*wareness-*R*etention-*C*urriculum model developed in this research provides a useful framework for conceptualizing and coordinating a program of activities to overcome the image problem and address recruiting needs. Most recruiting activities that are already being conducted, as documented in detail in Part 2 of this report, can be classified as awareness activities. Retention activities are of potentially much higher payoff, particularly in the near term, and follow the conventional marketing wisdom that it costs much less to keep an existing customer than to find a new one. Further, retention actions have already been developed and tested, in the context of minority engineering programs, and have been found to be highly effective. Curriculum actions follow the marketing logic that developing and offering improved products is an important strategy for attracting and retaining customers.

4. **Enhancement efforts should address all of the educational development stages of the civil engineer, from pre-school through college.** Recruiting activities cannot be limited to the high school and junior high school years. Attitudes formed early in life are long-lasting, so it is important to provide early positive exposure to engineering and other technical fields. Many important career-enhancing or career-limiting decisions are made prior to high school. Conscious career decision-making begins in the junior and senior high school years, and continues through college and beyond. A truly effective recruiting strategy will address all of these developmental levels, in a coordinated fashion.

5. **Enhancement efforts should target the adults who influence career choice decisions as well as students.** Parents, teachers, and guidance counselors often play pivotal roles in a student's curriculum and career choices. They are highly important information channels, and their support will be crucial to the success of any civil engineering career marketing program. Guidance counselors, in particular, are an untapped resource, who are often viewed by other teachers as the primary source of access to information about careers. Targeting adults will have the added benefit of improving the general public's knowledge about civil engineering.

6. **Enhancement efforts should effectively utilize existing programs.** As documented in this report, there are many programs that attack various elements of the desired effort to enhance the civil engineering pool. There is no need to replace existing efforts. Coordination and national leadership are the missing elements. A national effort would facilitate transfer of information and cooperation among the programs being conducted by the different engineering professional societies, government agencies, academic institutions, and other groups. There is also a need to work cooperatively with professional education and counseling organizations, such as the National Council of Teachers of Mathematics and the American School Counselors Association.

7. **Personal involvement of civil and transportation engineers is crucial to the success of efforts to enhance the civil engineering pool.** Role models are of singular importance in influencing young people to consider embarking upon a civil engineering career. This point emerged very strongly in the market research, as reported in Chapter 4. The most successful of the existing programs to attract students to technical careers feature strong interaction with practicing professionals. Civil engineering students can also be effective as role models. Professional societies can help by administering programs and by providing training and materials, but countless one-on-one interactions between civil engineering role models and students at all levels will be the key to success.

8. **Additional market research is needed.** While a good deal of marketing intelligence has been developed in this project, there is still more to learn. In the business world, a complete marketing program comprises the following elements: (a) *Market research and segmentation* — Identify market segments, and collect data on the wants and desires of each, and on the potential for changing their behavior. In the context of this project, additional research would be conducted on why different types of people do and do not select civil engineering as a career, and what it would take to change their choice behavior. (b) *Marketing mix* — For each market segment, develop the proper mix of the key variables: product, place, price, and promotion. These basically deal with the salient characteristics of both a civil engineering career and the civil engineering educational program, and how these characteristics can be altered to make them more attractive to the prospective "buyer." (c) *Test market* — Test the marketing mix developed for each segment via survey research, focus groups, field tests, and other methods to determine how well they meet the goals and objectives of the marketing program. Alter those mixes that fail to meet objectives. (d) *Full implementation* — After test marketing is successful, proceed with full implementation of the marketing program and conduct periodic reassessments to ensure that goals continue to be attained.

The present research project has identified and characterized a number of important market segments and has developed recommendations focusing on product and promotion. Test marketing for selected market segments will occur in Phase III of the project. Additional efforts to formalize the marketing framework, improve the precision and depth of market segmentation, and develop more fully the *place* and *price* attributes of the marketing mixes will yield useful results that can easily be incorporated into the ARC model for enhancing the civil engineering pool.

RECOMMENDATIONS

The basic recommendation resulting from this project is to adopt the ARC model, and further develop and implement the candidate action plans. Recognizing that all of this cannot be done immediately, the following recommendations are made for

Market Strategies	Pre-College			University	
	Elementary (Grades K-6)	Junior High (Grades 7-8-9)	Senior High (Grades 10-11-12)	Civil Engineering Students	Freshman/Sophomore Engineering Students
AWARENESS	Discuss technology and global engineering.	Present engineering as a career alternative with an introduction to civil engineering.	Provide civil engineering career information.	Provide civil engineering career information to: • Other engineering majors • Other institutions	Provide engineering career information to: • Other majors • Other institutions
RETENTION	Build confidence in mathematics and science.	Maintain confidence in mathematics and science.	Promote and retain technical interest.	Retain and graduate civil engineering students.	Retain and graduate engineering students.
CURRICULUM	Integrate early relevancy of mathematics and science.	Encourage further pursuit of mathematics and science.	Complete mathematics and science requirements.	Integrate early exposure to civil engineering disciplines.	Integrate early exposure to engineering disciplines.

Figure 4. Actions recommended for Phase III.

what to do next. Figure 4 shows the ARC matrix of candidate action plans and highlights those that are recommended for testing in Phase III of the research.

1. **Develop and test a coordinated set of Awareness actions, across all student developmental levels.** This recommendation is indicated by the shaded "Awareness" row in Figure 4. Although retention activities are believed to have a larger potential payoff, awareness must precede retention, and these actions are more suitable for the type of short-term, focused effort envisioned for Phase III. If resource limitations prohibit a broad-based program, efforts should focus on the high school and junior high school levels, where more direct targeting of civil engineering is possible.

2. **Develop and test a coordinated set of Awareness, Retention, and Curriculum actions at the high school level.** This recommendation is indicated by the shaded senior high school column in Figure 4. Whereas the first recommendation is to test the breadth concept of the ARC model, this one is to test the depth concept. High school is the pivotal time for selecting *civil engineering* from the math-science-engineering career spectrum, so the efforts of civil and transportation engineering organizations are particularly appropriate at this level.

3. **Develop and test Retention actions for civil engineering students.** As noted earlier, retention has great payoff potential. By focusing on the students who have already selected civil engineering, these actions capitalize on existing awareness and, again, merit and motivate the participation of civil and transportation engineers.

4. **Develop a complete marketing strategy for civil engineering careers.** This recommendation follows from the eighth conclusion stated previously. As noted, additional efforts are needed to define a formal marketing framework, broaden and strengthen the market segmentation research begun in this project, develop full marketing mixes for all of the market segments, and conduct additional test marketing. Most of the conceptual work could easily be incorporated into the Phase III research effort.

5. **Disseminate the findings of this research to a broad audience of civil engineering, engineering, and education decision-makers.** The shorter, summary level report prepared in this project is the appropriate vehicle to accomplish this recommendation. Wide distribution of that report will determine whether or not there is sufficient will and interest to proceed further. To benefit from this distribution, there must be a mechanism in place to champion implementation and to incorporate the constructive criticisms offered in response to the report. This needed mechanism is the subject of the next recommendation.

6. **AASHTO should spearhead the recommended national implementation effort.** AASHTO has already laid the groundwork for this, through its Committee on Recruitment and Retention and its sponsorship of the nascent Transportation and Civil Engineering (TRAC) Careers Center. AASHTO has excellent ties to the civil and transportation engineering professional societies, and could continue to facilitate coordination meetings on this topic. TRAC could directly undertake several of the action plans, and could foster more broadly based intersociety efforts to pick up most of the others. The location of AASHTO's members within state government also provides important access to the primary and secondary education establishment, whose cooperation is essential for many of the recommended actions.

REFERENCES

1. AMERICAN SOCIETY OF CIVIL ENGINEERS, "Civil Engineering Enrollment & Degree Data — 1989." ASCE, New York, N.Y. (Aug. 1990) 29 pp.

2. JOHNSTON, W. B. and PACKER, A. E., "Workforce 2000: Work and Workers for the 21st Century." Hudson Institute, Inc., Indianapolis, Ind. (June 1987) 117 pp.

3. TRANSPORTATION RESEARCH BOARD, "Transportation Professionals—Future Needs and Opportunities." *TRB Special Report 207,* National Research Council, Washington, D.C. (1985) 229 pp.
4. U.S. DEPARTMENT OF LABOR, Bureau of Labor Statistics, Press Release. *USDL 89-485* (1988) 2 pp.
5. ITE TECHNICAL COUNCIL COMMITTEE 2-32, "Attracting Students to a Professional Career in Transportation Engineering." *ITE J.,* Vol. 60, No. 1 (Jan. 1990) pp. 42–48.
6. LIBURDI, L. C., "Education and Training Needs of Women in Transportation." *TRB Special Report 210,* Transportation Research Board, National Research Council, Washington, D.C. (1984) pp. 184–191.
7. U.S. Cong., 99th 2d SESS., "Demographic Trends and the Scientific and Engineering Work Force." Report prepared by the Office of Technology Assessment. Transmitted to the Task Force on Science Policy of the Committee on Science and Technology, U.S. House of Representatives, Dec. 1986. U.S. Govt. Print. Office, Washington, D.C. (1987) 269 pp.
8. BROWN, J. R., "The Engineering Student Pipeline." *Eng. Ed.,* Vol. 78, No. 3 (May 1988) pp. 733–734.
9. U.S. Cong., 99th 2d SESS., "Demographic Trends and the Scientific and Engineering Work Force." Hearings before the Task Force in Science Policy of the Committee on Science and Technology, U.S. House of Representatives, Feb. 1986. U.S. Govt. Print. Office, Washington, D.C. (1986) 111 pp.
10. VETTER, B. M., "Demographics of the Engineering Student Pipeline." *Eng. Ed.,* Vol. 78, No. 3 (May 1988) pp. 735–740.
11. LANDIS, R. B., "The Case for Minority Engineering Programs." *Eng. Ed.,* Vol. 78, No. 3 (May 1988) pp. 756–761.
12. GEDNEY, D. S., "Educating 21st Century Highway Engineers—Industry Perspective of Highway Engineer Needs." *Proc., Conf. on Engineering 21st Century Highways,* San Francisco, Calif. (Apr. 1988) pp. 216–221.
13. "Women in Engineering." *Eng. Manpower Bull.,* No. 99 (Feb. 1990) 6 pp.
14. "Minorities in Engineering." *Eng. Manpower Bull.,* No. 97 (Oct. 1989) 6 pp.
15. ELLIS, R. A., "Engineering and Engineering Technology Degrees, 1989." *Eng. Ed.,* Vol. 80, No. 3 (Apr. 1990) pp. 391–422.
16. ALEXANDER, J. A., "Professionalism and Marketing the Profession of Civil Engineering." *J. Professional Issues Eng. Ed. and Practice,* Vol. 117, No. 1 (Jan. 1991) pp. 10–20.
17. "Female Engineering Graduates Received Highest Salary Offers in 1990." *Eng. Ed. News,* Vol. 17, No. 5, American Society for Engineering Education, Washington, D.C. (Dec. 1990) p. 1.
18. "Labor Market Conditions for Engineers: Is There a Shortage?" National Research Council, Washington, D.C. (1984) pp. 89–92.
19. *"TRACE" Careers Center.* A Non-Profit Organization, Draft Prospectus, American Association of State Highway and Transportation Officials, Washington, D.C. (Apr. 25, 1990) 34 pp.
20. "Transportation Professionals: Recruitment and Retention." American Association of State Highway and Transportation Officials, Washington, D.C. (Nov. 1988) 48 pp.
21. "The AASHTO Guide to Recruitment and Retention of Civil Engineers." American Association of State Highway and Transportation Officials, Washington, D.C. (1990) 125 pp.
22. "Summer Transportation Intern Program for Diverse Groups." U.S. Department of Transportation, Federal Highway Administration, Research and Special Programs Administration, Urban Mass Transportation Administration, Washington, D.C. (1991) 6 pp.
23. PAYNE, E., Federal Highway Administration, National Highway Institute, Personal Communication (Feb. 1991).
24. "Engineering State: Project Profile at Utah Water Research Laboratory." *Aquarius,* Vol. 19, No. 3 (July 1990) p. 1.
25. TOBIN, A., "PRIME: A Model Precollege Minority Program." *Eng. Ed.,* Vol. 78, No. 8 (May 1988) pp. 747–749.
26. DEUTSCHMAN, H., "Attracting Students for the 21st Century." *Education and Continuing Development for the Civil Engineer,* American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 224–227.
27. BAUM, E., "Transfer Students in Engineering Education." *Eng. Ed.,* Vol. 78, No. 8 (May 1988) pp. 769–771.
28. SCHULER, K. H., "Career Education and the Engineering Team." *Education and Continuing Development for the Civil Engineer,* American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 411–417.
29. "Educating Tomorrow's Engineers: A Guide to Precollege Minority Engineering Programs." Mathematics, Engineering, Science Achievement Program/Minority Engineering Program, National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1989) p. 8.
30. DANIELS, J. Z., "Women in Engineering: A Program Administrator's Perspective." *Eng. Ed.,* Vol. 78, No. 8 (May 1988) pp. 766–768.
31. UTLEY, G., "Becoming a Master Engineering Student." *Education and Continuing Development for the Civil Engineer,* American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 449–455.
32. AMERICAN SOCIETY OF CIVIL ENGINEERS, Draft Report and Policy Statement. Joint Task Committee on Career Guidance, ASCE, New York, N.Y. (Nov. 1990) 25 pp.
33. MUNSKI, K. D., "Activity of the ASCE Committee on Career Guidance, Education, and Continuing Development of the Civil Engineer." American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 444–448.
34. CRAIG, R. J. and CABLE, J. K., "The Faculty Advisor of an ASCE Student Chapter." *Education and Continuing Development of the Civil Engineer,* American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 490–496.
35. "Civil Engineering in the 21st Century: A Vision and a Challenge for the Profession." Prepared by the Task Committee to Plan Conference on Civil Engineering Research Needs, American Society of Civil Engineers, New York, N.Y. (1988) 11 pp.
36. HOEL, L. A., FRANCOIS, F. B., and LLOYD, G. R., "Where Will We Get the Transportation Engineers and Planners of Tomorrow?" *Transportation Research Record 1243,* Transportation Research Board, Washington D.C. (1990) pp. 54–60.
37. "Executive Summary and Recommendations of the Steering Committee." *Education and Continuing Development*

for the Civil Engineer, Vol. 2, American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. vii–xiii.
38. HOEL, L. A. and GRAY, G. E., "Conclusions and Recommendations: Transportation." *Education and Continuing Development for the Civil Engineer,* Vol. 2, American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 99–106.
39. NAIDUS GROUP, "Marketing Plan for Career Guidance." American Society of Civil Engineers, New York, N.Y. (July 1990) 67 pp.
40. NAIDUS GROUP, "Focus Sessions on a Possible ASCE Program to Attract Qualified Students into the Profession." Preliminary Report of Findings, American Society of Civil Engineers, New York, N.Y. (May 18, 1990) 18 pp.
41. BLACHMAN, M. M., "ITE's Mission: As Challenging and Timely as Ever." *ITE J.,* Vol. 59, No. 12 (Dec. 1989) pp. 13–15.
42. ROBERTSON, D. H., "Promoting the Profession: The Role of Student Chapters." *ITE J.,* Vol. 59, No. 11 (Nov. 1989) pp. 15–16.
43. "Attracting Students to a Professional Career in Transportation Engineering." Final Report by Technical Council Committee 2-32, Institute of Transportation Engineers, Washington, D.C. (1989) 26 pp.
44. NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS EDUCATION FOUNDATION, Pre-College Career Guidance Committee Activities, NSPE, Alexandria, Va. (1990) 2 pp.
45. "Training Today's Talent for Tomorrow's Technology." Flyer, National Engineering Design Challenge, National Society of Professional Engineers, Alexandria, Va. (1990).
46. "Discover 'E' Engineering our Environment." Promotional Packet, National Engineers Week, National Society of Professional Engineers, Alexandria, Va. (Feb. 17–23, 1991).
47. "MathCounts: Nationwide Junior High Math Program." Flyer, National Society of Professional Engineers, Alexandria, Va. (n.d.).
48. MICHAEL, H. L., "Attracting Students to a Professional Career in Transportation Engineering." Purdue University *Eng. Bull.* (Mar. 1989) pp. 4–17.
49. DALEY, H. M., DEMETRY, C., and KUTCHUKIAN, P. D., "Career Guidance in Engineering." National Society of Professional Engineers, Alexandria, Va. (Dec. 1986) 12 pp.
50. "A Program of Scholarships for the Study of Engineering." Engineering Society for Advancing Mobility, Land, Sea, Air, and Space, Warrendale, Penn. (1989) 8 pp.
51. "Vision 2000: An Education Partnership Today for Insuring Tomorrow's Mobility Engineers." Engineering Society for Advancing Mobility, Land, Sea, Air, and Space, Warrendale, Penn. (1990) 12 pp.
52. "National Organizations of the United States." *Encyclopedia of Associations,* Vol. 1, Part 1, 20th Ed. (1986) p. 643.
53. HYMAN, B., "Engineers and Government: A WISE Relationship." *Eng. Ed.,* Vol. 79, No. 8 (Dec. 1989) pp. 1010–1014.
54. HYMAN, B., "An Education Based Approach to Enhancing a Public Policy Role of the Engineering Profession." *Internat. J. Appl. Eng. Ed.,* Vol. 4, No. 6 (1988) pp. 487–497.
55. "Students Engaged in Engineering." Brochure, American Consulting Engineers Council (ACEC), Washington, D.C. (1991).
56. "National Organizations of the United States." *Encyclopedia of Associations,* Vol. 1, Part 1, 20th Ed. (1986) p. 515.
57. "ASEE Plans Precollege Action." *Eng. Ed. News,* Vol. 17, No. 2, American Society for Engineering Education, Washington, D.C. (Sept. 1990) p. 3.
58. "U.S. National Chemistry Olympiad." Pamphlet, The Education Division, American Chemical Society, Washington, D.C. (1988) 16 pp.
59. "Educational Policies for National Survival." American Chemical Society, Washington, D.C. (Nov. 1989) 13 pp.
60. "Education Division Program Summaries." American Chemical Society, Washington, D.C. (May 1988) 12 pp.
61. "Education Division Programs—Pre-High School Science." American Chemical Society, Washington, D.C. (Feb. 1990) 10 pp.
62. KUNZ, D. W., "The Junior Engineering Technical Society (JETS): Exploring the World of Tomorrow—Today." *Proc., Conf. on Pre-College Education of Minorities in Science and Engineering,* New Jersey Institute of Technology, Newark, N.J. (May 1988) pp. 62–64.
63. MCDONALD, J., CLARKE, M. K., and DOBSON, E. N., "Increasing the Supply of Women and Minority Engineers: An Agenda for State Action." National Governors Association, Washington, D.C. (1990) 51 pp.
64. "Guide to Programs, Fiscal Year 1990." National Science Foundation, *NSF 89-68,* Washington, D.C. (1989) 101 pp.
65. "Engineering Education Coalitions Program." National Science Foundation, *NSF 89-107,* Washington, D.C. (1989).
66. "Join the Explorers." *Eng. News Rec.,* Vol. 223, No. 25 (Dec. 21, 1989) p. 6.
67. "Changing America: The New Face of Science and Engineering." Task Force on Women, Minorities, and the Handicapped in Science and Technology, National Science Foundation, Washington, D.C. (Dec. 1989) 45 pp.
68. "Penn State Becomes Space Grant University." *The Daily Collegian,* University Park, Penn. (July 3, 1990) p. 5.
69. *Westinghouse Foundation Annual Report.* Pittsburgh, Penn. (1989).
70. SPRINGER, C., "Overview and Impact of the Westinghouse Steering Committee for Minority Communications." *Proc., Conf. on Pre-College Education of Minorities in Science and Engineering,* New Jersey Institute of Technology, Newark, N.J. (May 1988) pp. 117–122.
71. "Training Today's Talent for Tomorrow's Technology." National Engineering Design Challenge, Flyer (n.d.).
72. GNAEDINGER, J. P., TOBIN, H., KAZARIAN, G., and GETZENDANNER, J., "Students: The Future of Civil Engineering." *Education and Continuing Development for the Civil Engineer,* Vol. 2, American Society of Civil Engineers, New York, N.Y. (Apr. 1990) pp. 348–405.
73. "Expanding Horizons From Coast to Coast." *Broadcast.* The Math Science Network, Berkeley, Calif. (Winter 1990) p. 1.
74. SOCIETY OF HISPANIC PROFESSIONAL ENGINEERS, Brochure. Los Angeles, Calif. (n.d.).
75. RAMSEY, J. N., "Educating American Indian Youth, as Supported by The American Indian Science and Engineering Society." *Proc., Conf. on Pre-College Education of Minorities in Science and Engineering,* New Jersey Institute of Technology, Newark, N.J. (May 1988) pp. 137–141.
76. AMERICAN INDIAN SCIENCE and ENGINEERING SOCIETY,

Boulder, Colo., Brochure (n.d.).
77. "Promoting Success in Math, Science, and Technology." National Association of Precollege Programs, Organizational Directory, New York, N.Y. (1989–1990) 14 pp.
78. RICKS-DRAYTON, J., and SECME STAFF, "How Educators Can Prepare Pre-College Students to Enter the Study of Engineering." *Proc., Conf. on Pre-College Education of Minorities in Science and Engineering,* New Jersey Institute of Technology, Newark, N.J. (May 1988) pp. 37–41.
79. SOUTHEASTERN CONSORTIUM FOR MINORITIES IN ENGINEERING, "Educating Tomorrow's Engineers: A Guide to Precollege Minority Engineering Programs." National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1989) p. 33.
80. TEXAS ALLIANCE FOR MINORITIES IN ENGINEERING, INC., "Educating Tomorrow's Engineers: A Guide to Precollege Minority Engineering Programs." National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1989) p. 99.
81. "Engineering the Future." *1989 Annual Report,* National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1989) 20 pp.
82. "Educating Tomorrow's Engineers: A Guide to Precollege Minority Engineering Programs." National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1989) 146 pp.
83. LANDIS, R. B., "Academic Gamesmanship: Becoming a Master Engineering Student." National Action Council for Minorities in Engineering, Inc., New York, N.Y. (1987) 20 pp.
84. COLEMAN, B. C., "Minority Enrollment Stagnant in Medicine." *Centre Daily Times,* State College, Penn. (Aug. 15, 1990) p. 4A.
85. GROSSMAN, D., ARNOLD, L., SULLIVAN, J., PAMERON, M. E., and MUNRO, B., "High School Students' Perception of Nursing as a Career: A Pilot Study." *J. Nursing Ed.,* Vol. 28, No. 1 (Jan. 1989) pp. 18–21.
86. TYSINGER, J. W. and WHITESIDE, M. F., "A Review of Recruitment and Retention Programs for Minority and Disadvantaged Students in Health Professions Education." *J. Allied Health,* Vol. 16, No. 3 (Aug. 1987) pp. 209–217.
87. *Federal Register,* Vol. 55, No. 148, U.S. Govt. Print. Office, Washington, D.C. (Aug. 1, 1990) pp. 31235–31236.
88. "HCOP Digest." U.S. Department of Health and Human Services. U.S. Govt. Print. Office, Washington, D.C. (1989) 139 pp.
89. AMERICAN ASSOCIATION OF COLLEGES OF NURSING, "Summary Report: Generic Baccalaureate Nursing Data Project (1983–1986)." AACN, Washington D.C. (1986) 15 pp.
90. "Concern Deepened Over Nurse Shortage." *Philanthropic Update,* Vol. 1, No. 1 (Feb. 1991) p. 7.
91. FEDERAL AVIATION ADMINISTRATION, "Careers in Airway Science." U.S. Department of Transportation, Washington, D.C. (1990) 6 pp.
92. AYELE, M., "Attracting Minorities to the Transportation Profession: HBCU Perspective." Paper No. 910063, 70th Annual Meeting, Transportation Research Board, Washington, D.C. (Jan. 13–17, 1991).
93. DISARIO, P. C., "A Proposal for Improving the Image of Engineers." *Civ. Eng. News* (May 1990) p. 8.
94. STRINGER, T. G., "The So Called Engineer Shortage Theory Comes Up Short." *Civ. Eng. News* (May 1990) p. 9.
95. "Engineering and Related Occupations." *Occupational Outlook Handbook,* U.S. Department of Labor, Bureau of Statistics, Washington, D.C. 1987–1988 Ed. (1987) 19 pp.
96. "Women and Minorities in Science and Engineering." National Science Foundation, *NSF 90-301,* Washington, D.C. (Jan. 1990) 166 pp.
97. SAIGAL, A., "Women Engineers: An Insight into Their Problems." *Eng. Ed.,* Vol. 78, No. 3 (Dec. 1987) pp. 194–195.
98. "The Cooper Union 1989 National Survey of Undergraduate Women Engineering Students." Albert Nerken School of Engineering, The Cooper Union for the Advancement of Science and Art, New York, N.Y. (1989) 11 pp.
99. "The Cooper Union 1989 National Survey of Women Engineers." Albert Nerken School of Engineering, The Cooper Union for the Advancement of Science and Art, New York, N.Y. (1989) 8 pp.
100. CARTER, R. and KIRKUP, G., "Critical Influences in the Career Choice of Women Engineers." *U.S. Woman Engineer,* Vol. 36, No. 1 (Jan./Feb. 1990) pp. 23–25.
101. "In Search of a Job Description." *Civ. Eng.,* Vol. 60, No. 5 (May 1990) p. 10.
102. CARTER, R. and KIRKUP, G., *Women in Engineering: A Good Place to Be?* Macmillan Education Ltd., Houndsmills, Baringstone, England (1990) 194 pp.
103. AMERICAN SOCIETY OF CIVIL ENGINEERS, "Civil Engineering Degree Data — 1988." ASCE, New York, N.Y. (Sept. 1989) 13 pp.
104. JONES, R. C., "The Coming Personnel Shortage." *Civ. Eng.,* Vol. 60, No. 6 (June 1990) pp. 6, 10.
105. LANE, M. J., "The Current Status of Women and Minorities in Engineering and Science." *Eng. Ed.,* Vol. 78, No. 8 (May 1988) pp. 750–755.
106. HITCHNER, K. W. and TIFFT-HITCHNER, A., "Making a Difference in College Admission." The Center for Applied Research in Education, West Nyack, N.Y. (1989) 25 pp.
107. IVEY, E. S., "Recruiting More Women." *Eng. Ed.,* Vol. 78, No. 8 (May 1988) pp. 762–765.
108. METZ, S. S. and CAMPBELL, P. B., "What Does it Take to Increase the Number of Women Majoring in Engineering?" *Proc., Annual Conf. Am. Soc. Eng. Ed.,* Reno, Nev. (1989) pp. 882–888.
109. KAMBER, D. M., "It Takes More Than Money." *Eng. News Rec.,* Vol. 223, No. 21 (Nov. 23, 1989) p. 9.
110. LEVENTMAN, P. G. and HORST, L., "Cooperative Education and Women in Engineering Careers." *IEEE Trans. Ed.,* Vol. E-28, No. 4 (Nov. 1985) pp. 210–214.
111. ESTRIN, T., "Women in Engineering: A Decade of Progress." *IEEE Trans. Ed.,* Vol. E-28, No. 4 (Nov. 1985) pp. 181–183.
112. FISHER, H. E., "Precollege Engineering Programs for Minorities: Which Approach is More Effective?" *Eng. Ed.,* Vol. 75, No. 3 (Dec. 1984) pp. 115–117.
113. "Keeping the Options Open: An Overview." Interim Report, Commission of Pre-College Guidance and Counseling, The College Entrance Examination Board, New York, N.Y. (Jan. 1986) 53 pp.
114. "Retention of Minority Students in Engineering." Retention Task Force Committee on Minorities in Engineering,

National Research Council, Washington, D.C. (1977).
115. NICKOLAI-MAYS, S. and KAMMER, P. P., "Non-White Students' Concerns About Attending College." *The School Counselor,* Vol. 34, No. 5 (May 1987) pp. 379–383.
116. RUDNICK, D. T., "Minority Students: Understanding a New Clientele." *Eng. Ed.,* Vol. 75, No. 8 (May 1985) pp. 696–700.

APPENDIXES A THROUGH E

UNPUBLISHED MATERIALS

Appendixes A, B, C, D, and E of the final report are not published herewith. They are included under separate binding in the agency-prepared report entitled, "Expanding the Civil Engineering Pool," Final Report, October 1991. A limited number of copies of that report are available on loan or for purchase at a cost of $10.00, from the NCHRP, Transportation Research Board, Business Office, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

The titles and "contents" of the available appendixes are listed here for the convenience of those interested in the subject area:

- Appendix A—Summary of the Practices of State Highway Agencies and Departments of Transportation to Increase and Maintain Interest in Civil Engineering as a Career (Tables summarizing efforts by state highway agencies and departments of transportation to increase interest in civil engineering, engineering, and mathematics and science: career and support programs, preemployment development programs, and post-employment development programs).
- Appendix B—Summary of the Practices of the Departments of Civil Engineering and Civil Engineering Technology to Increase and Maintain Interest in Civil Engineering or Mathematics and Science (Tables summarizing civil engineering department and civil engineering technology department activities to increase interest in civil engineering: pre-college and undergraduate career information, support programs, and activities).
- Appendix C—Examples of the Programs Used by Educational Institutions to Increase and Maintain Interest in Mathematics, Science, and Engineering (Tables and narrative describing career guidance programs, college orientation programs, cooperative education programs, family programs, intervention programs, mentor and protégé programs, teacher training programs, television and public radio programs, and tutorial services programs).
- Appendix D—Summary of Practices Used by Professional, Resource, Governmental, and Industrial Organizations to Increase Interest in Civil Engineering and Mathematics, Science, and Engineering (Tables and narrative pertaining to support of activities including integrated programs, pre-college programs, video and printed materials, scholarships, internships, role model and mentor programs, contests and fairs, career days, field trips and tours, teacher workshops, instructional materials, and family programs).
- Appendix E—Summary of Practices of Other Engineering and Science Disciplines (tables and narrative summarizing efforts of other engineering professional societies to increase interest in their professions).

APPENDIX F

DOCUMENTATION OF MARKET RESEARCH STUDY

This appendix presents the results of an intensive research study conducted among a wide sampling of "universes" which in greater or lesser ways relate to the Civil Engineering profession.

This is a complex profession in a complex field and, in no way, can only 17 intensive group sessions provide totally definitive results either in findings or conclusions and recommendations. Considering the variations of geography and societal background, many of the various segments studied were investigated only once or, at best, only twice. Thus, although what is reported herein can justifiably be regarded as "valid" information, it cannot be viewed as "statistically reliable" information.

The basic philosophy of group research of this kind is to provide a broad variety of market segments with pointed stimuli in the form of questions, ideas, and other aids in order to obtain from them a broad array of reactions. These reactions, in turn, become a higher order of idea stimuli to the executors of this research program, to those people who observed each of the group sessions and participated in post-group critiques, to those people who observed the videotapes of each group and, finally, to those people who are reading this very report. This secondary stimulus process is indeed the major function of the research process.

It is conceivable that some of the findings herein may not be consistent with any reader's prior beliefs or experiences. Depth research inevitably creates such "problems." The reader and those others who will ultimately participate in the creative process leading to effective strategies must deal with these "problems" and must seek for an understanding of why people say the things they do in groups.

In this sense the reader should understand the structure of a report of this kind. The *Findings,* indeed, represent an organized presentation of "what happened" in the groups. Raw group data are organized and analyzed and should be taken at face value. To repeat, it represents ***"WHAT HAPPENED"!***

Conclusions represent the interpretation of these *Findings* data. These interpretations are those of the research company's own staff integrated with observer interpretations proceeding from the intensive critiques following each group. Obviously, they are subject to argument and to the interpretation of other readers. *Recommendations,* where they exist, follow the same philosophy. To whatever degree possible, each *Recommendation* as stated uses *Conclusions* as evidence.

Obviously, other readers may draw conclusions and recommendations based on their own background and experience. This is the plan of the whole program.

Throughout this report frequent use is made of comments by respondents. In many cases these are precisely "verbatim." In other cases, however, they are "representative" of what one or more respondents may have said on a subject.

DOCUMENTATION OF MARKET RESEARCH STUDY

INTRODUCTION

Civil Engineering is sometimes described as one of the oldest professions known to mankind. Civil engineers have played vital roles throughout history in developing many of the great wonders and some less heralded necessities of civilization. In various periods of history they have been viewed as some of the most revered citizens.

Over the last 30 years, our society has gone through massive growth both in general and in terms of technology. These changes in society have served to increase the demand for all kinds of engineers, including civil engineers. Increases in building sophistication coupled with overcrowded metropolitan areas promise an even greater need for civil engineers in the years to come. In fact, demographers and other experts have predicted that, if current patterns hold, there could well be severe shortages of civil engineers in the near future.

Given the potential shortages of civil engineers, state and private organizations that rely on civil engineers must become more effective at expanding the pool of young people entering the profession. They must know how to motivate appropriate and capable young men and women to become civil engineers.

In this regard, one of the first challenges they must meet is to understand how such young people make decisions about their careers. This implies understanding the influences on their decision-making process as well as their underlying attitudes toward the field. This task is complicated by the fact that career decisions are not made overnight, but rather are based on years of influences. Moreover, the nature of these influences and the decision-making process may very well differ among individuals of different social, ethnic and racial groups. Only after the decision-making process and attitudes are fully understood can strategic approaches be developed for attracting young people into the field.

This report presents the results of an in depth research investigation conducted to help provide that understanding of societal attitudes toward civil engineering as a career and how young people make their career decisions. The investigation was designed to provide insights into the best strategies of increasing the pool of civil engineers. What follows is a description of the research design.

METHODOLOGY

The fundamental objective of this project is to understand how and why people make the career decisions they do as well as to determine what the underlying attitudes are toward civil engineering and other professions. In order to provide the deep and clear insights into these issues necessary to achieve those goals, a sophisticated form of qualitative research is required.

This study was conducted using the depth group interview as uniquely practiced by The Brand Consulting Group. This technique is based more upon a "stimulus/reaction" depth interviewing format and much less to a "question/answer" format. Thus, the classical market research approach is replaced with one more couched in psychiatric group theory. Its first element of difference is the depth of information it reveals. The researcher uses the group effect as well as an arsenal of individual probing techniques to uncover those hidden attitudes and motivations that control perception and behavior. This kind of group session usually lasts between an hour and a half and two hours.

This technique involves ten people, more or less, sitting in discussion with a highly trained senior research professional who acts as moderator. The moderator is quite experienced and skilled at stimulating and probing respondents to uncover their deepest insights. Questions, idea stimuli, concepts, printed brochures and even video materials are exposed to students for their reactions. In the probing efforts, in this regard, the moderator does not "allow" individuals to "answer" with easy, "top-of-the-head" answers. Respondents are challenged. If necessary, actual arguments ensue. In short order the entire group catches the spirit of the procedure and cooperates with the leader. All begin to challenge each other not to give the first facile answer. Each respondent in turn finds that his attitudes are subjected to the glare of such scrutiny.

The moderator in such a group is, of course, stimulated by what people say and, because of experienced creativity, will usually come up with "on-the-spot" hypotheses which rationalize the particular behavior patterns being solicited from the panelists. A moderator, thus, will frequently interrupt a session to present to the group what he purports to be a "summary" of what has transpired to that point. What looks to the observer like "leading" is, in essence, a "feedback" to the group of hypotheses that have been designed to rationalize observed group behavior. Group acceptance of the "summary" as correct serves as an early indication of the validity of the hypotheses.
The objective here, of course, is to reach into the respondents' minds in a broader, deeper fashion than is possible through the more structured technique of individual interviews. Respondent reactions to moderator stimuli is augmented by stimuli from other group members. The result is an understanding of how an intricate combination of physical and emotional stimuli can create various sets of attitudes which in turn are the precursors of image, perception and, ultimately behaviors.

The process of making career decisions is long and complicated. It begins in the earliest years of ones life as one is exposed to different professions and even continues through the time one is employed and occasionally changes careers. During the course of these decision making years there are numerous influences which must be considered including family, friends and school. Moreover, the decision process and the nature of these influences may very well differ among different classes of individuals.

This study utilized a complex design that took into consideration a wide variety of these influences. A total of 17 group discussions were conducted among the following classes of individuals.

- Three sessions were conducted among parents with children in junior and senior high school. Parents were included for their obvious ability to discuss influences that may occur in the home. In doing so they reveal their own attitudes and biases. They also can most effectively discuss other early childhood influences.

- Two sessions were conducted among junior high school students. Experience has shown that the junior high school years are associated with a significant increase in the intensity of the decision making process. These students were able to discuss their attitudes toward specific classes, exposure to careers and current attitudes, perceptions, biases and other influences on them.

- Three sessions were conducted among high school students. High school students were able to discuss the same issues as the junior high school students. These students, of course, are approaching the apex of their decision making process -- the critical years which occur just prior to entering college.

- Four groups were conducted among college students. College students were included so that they could be probed on their recall of their decision making process prior to entering college -- as well as their experiences in college.

- One session was conducted among high school math and science teachers. Because their subject matter is so important to the engineering fields, they play an important role in influencing students. They are able to discus both students' perspectives toward math, science and careers and the role of career planning in their curriculum.

- One session was conducted among junior and high school counselors. They discussed some of the same issues as the teachers as well as their role in academic and career planning.

- Two sessions were conducted among civil and other engineering professors. These individuals were able to discuss both the academic perspective and their own views of the marketplace. The professors also watched student group sessions prior to their own to provide further stimulus for their input.

- One session was conducted among practicing civil engineers who were able to discuss the attractiveness of a career in civil engineering from their own perspectives.

Beyond these classifications, an effort was also made to gain an understanding of the differing attitudes and experiences among key demographic groups such as men, women, African-Americans, whites and Hispanic-Americans. Below is a chart which indicates the seventeen actual groups conducted and where.

	All White	All African-American	All Hispanic-American	Mixed
Junior High Students	Lafayette, Indiana		Austin, Texas	
Senior High Students	Los Angeles, California	Pittsburgh, Pennsylvania	Los Angeles, California	Austin, Texas
College Students	St. College, Pennsylvania	Lafayette, Indiana	Los Angeles, California	Austin, Texas
Parents	Lafayette, Indiana	Los Angeles, California	Austin, Texas	
Junior/High School Counselors				Los Angeles, California
Junior/High School Teachers				St. College, Pennsylvania
College Professors				Los Angeles, CA Lafayette, IN
Practicing Civil Engineers				Pittsburgh, Pennsylvania

Aside from these very general characteristics, each session also had additional selection criteria.

- All junior high and high school students were selected on the assumption that they were likely to attend college.

- All junior and senior high school students and parents of these students were screened to assure that they did not have a strong aversion to math and science.

- The college students were selected to provide a mixture of civil engineering, other engineering and other math and science majors.

The specific questionnaires used in screening respondents have been included in the back of this report in Appendix A.

In general, the sessions were conducted in a manner to allow for open, free-flowing, unencumbered discussion. Discussion guides were developed for each of the sessions to insure that relevant subject matter was covered. Each of these discussion guides covered the following issues.

- Attitudes toward different types of course work including specific discussions of math and science classes. This included attitudes toward the subject matter, the teachers and how the class is taught.

- Attitudes and influences in the career decision making process.
- Attitudes toward different career categories including both the characteristics of an ideal career and their attitudes toward specific careers. This included both unaided and aided discussions of a variety of careers.
- Awareness of their attitudes toward the field of engineering in general as well as specific areas of specialization.
- Detailed discussion of the field of civil engineering, reasons why it is and is not an attractive field for a career. This included exposure to various stimulus materials including promotional video tapes.

A copy of the actual discussion guides utilized may be found in the back of this report in Appendix B.

All sessions were conducted between September 25 and October 30, 1990. The sessions were both audio and video tape recorded and were viewed by key project personnel who participated with the group moderator in intensive post-group critiques.

CONCLUSIONS AND RECOMMENDATIONS

We have reviewed the findings of this study as they are presented later in this report. We have further taken into consideration each of the post-group critiques. Based on these efforts and our interpretations of these findings we have developed the following conclusions and recommendations.

1) Clearly, the primary inhibiting factor to the attraction of students to the field of civil engineering is the fact few know anything about it. That which is perceived to be known about it is quite often in error. This is clearly the case with young junior high students and also high school students. It is also the case with many of their parents. It is even the case, unfortunately, among many college students! Teachers and counselors in many of the school districts included in this study appear to know only slightly more, but apparently have neither the time nor inclination to foster interest. Specifically ...

   - There is clearly very little time spent on exposing students to potential careers during their primary education. Teachers feel they barely have enough time to cover their required curriculum. Others lack the creativity or motivation to incorporate it into their curriculum. Many school districts do not even have anyone charged with career guidance.
   - Because of this lack of early focus on career decisions, there is relatively little detailed awareness of most career opportunities among young people. Their awareness is currently generated almost exclusively by their exposure to the careers of other members of their immediate family, friends and those careers to which they are exposed in the mass media. Of course this creates particular biases especially among lower socio-economic households where the breadth of such exposures is often more limited. Similarly, women are not exposed to female role models in technical fields as often as are males.

2) While there has been some concern that students' apprehension about math and science courses could inhibit their interest in technical fields, we did not find this to be an inherent problem. Rather it appears to be a problem associated more directly and frequently with the quality of their teachers in these fields. Poor math teachers in particular have a domino effect over the years on children's' attitudes toward the field. There is a clear need for improved training of math teachers in how to motivate students in the classroom. This must include showing the relevance of the subject to real life as well as improving their ability to answer student questions.

3) The field of engineering in general is an enigma to most young people and their parents. Many are aware that there is great demand for engineers. Some understand that it is a field particularly appropriate for those adept in math and science. There is very little specific understanding, however, about what an engineer really does. This was even found to be true among freshman entering engineering programs at the college level! At best, some felt that engineers were simply the people who built bridges and roads! The lack of awareness among incoming freshmen was compounded by the perception that the engineering curriculum was very demanding and that if a student did not commit to it as a freshman, it would be nearly impossible to graduate in four years.

4) The field of civil engineering above all other engineering fields is plagued by a combination of a complete lack of awareness and misunderstanding. The phrase "civil engineer" is not a familiar one to young people -- nor to their parents! Moreover, unlike some other fields, the name does not accurately communicate an explanation of the field. Even worse is the fact that some of those few people who have some impression of the field relate it to either "the men who drive around in yellow trucks and work for the county," or to those "incompetents who can never explain the problem with a bridge or road when a disaster occurs."

5) While the connotation of "civil engineering" in general fails at communicating an imagery, some of the specialties within the field are far more effectively understood. Thus, individuals can understand what a transportation, structural, construction and environmental engineer might do. These specific fields have far more meaning than does the more general field of "civil engineering."

We suggest there is a clear opportunity to improve the imagery of the field as well as to create interest in it by effectively communicating and promoting its specialties more heavily than the more general field. The general field of civil engineering then can become a common link among them all. "Structural Engineering -- a civil engineering specialty."

6) The challenge of creating interest in civil engineering goes beyond simply redefining its name and generating basic awareness, however. Simple explanations of the field tend to leave individuals cold. Many young individuals appear to take our roads, bridges and buildings "for granted." They believe that there is relatively little future need for large quantities of additional buildings and that what will be built has become routine, "All the problems have already been solved."

   We suggest that the challenge facing this field is one of communicating the exciting issues and challenges facing the civil engineer in the 21st century! These need to be presented in a way that young people can understand and relate to them and be excited about them! A small example is the roller coaster analogy used in the ASCE video "Dream Your Own Dream" to which young people can truly relate -- or even more exciting "Intelligent Vehicle/Highway Systems." This is particularly important for the transportation specialty which many perceive as the most mundane.

7) Beyond the obvious "glamour" issues the civil engineer will tackle in the future, there are numerous other elements of the field which can be utilized to make the field perceived to be more attractive to young people.

   - Young people are very concerned about the future demand for specific fields in terms of their ability to find a job, experience progress within it and make good money. These very issues along with a "selling" of the perception of "stability, that society will always have for the civil engineering profession (we will always need roads), need to be stressed.

   - The truly exciting and unique breadth of specific job opportunities available to the civil engineer is also an attractive issue to be utilized in promotional activities. For instance, the notion of working either in the field or in an office (or both), of working as a designer or a supervisor, working in management or working as a consultant offer job type flexibilities that few other career options offer.

   - There is also a uniquely strong opportunity for civil engineers with an entrepreneurial inclination. This is a significant career goal for many young people. It appeared to be particularly attractive to minorities and women. They particularly expressed interest in this both as a way to overcome discrimination in large organizations and as an opportunity to contribute back to their communities.

   - The fact that civil engineering is a licensed profession also offers opportunities for building positive images of the profession. It can be viewed as providing a degree of professionalism and exclusivity to the field which many find attractive. It causes it to be perceived as a "higher image" kind of job.

7) We find that for the most part career decision-making criteria and attitudes toward engineering and civil engineering in particular are fairly consistent among different races and sexes. We believe the same arguments and programs should be implemented for all groups. Greater exposure levels will be required though for minorities and women to overcome disparities in awareness and perceptions due to their lack of historical involvement.

   - There is a perception among some minorities and women that there is a "glass ceiling" that will eventually limit their growth potential in the field. While it does not appear to have inhibited the group participants' interest, it may well have kept others out of the field. It is important that this issue be addressed from both an infrastructure perspective, to eliminate the problem, and from an imagery perspective (role models).

   - Outreach programs in lower and middle class neighborhoods in general could be important as these individuals are less likely to be exposed to the field on their own. This should include programs designed to expose them to fields through mentors who can demonstrate their potential for success and through internships and academic programs which will stimulate their interest intellectually.

   - Some form of support should be provided to women and minorities as they enter the work force. This could include college seminars on skills required to succeed in organizations as well as support groups.

8) There are a number of opportunities available for improving awareness of the field of civil engineering that should be considered for future implementation by the profession.

   - The field can improve its imagery through public relation self-promotion. It needs to communicate its role in successful projects of all kinds. Its important role in society should be made apparent -- frequently, impactfully. The single biggest deterrent to young people is they don't know what it's really about -- or that it is a dull and even dirty field.

   - The field is currently described and discussed in career guidance computer databases and other resource materials utilized in schools across the country. A review of these materials should be made followed by efforts to improve the descriptions so as to provide a more accurate and favorable view of the profession.

Comments made by students who have used these systems indicate a wide disparity of quality and effectiveness.

- We believe there are opportunities to promote awareness of the field and excitement about it in young people through some form of personal involvement. In the groups some teachers even suggested the use of contests akin to science fairs. They talked of projects such as building bridges out of straws, buildings out of popsicle sticks and so on. They believe this would foster involvement and this would encourage young people to develop creativity and motivate exploration of the issues of the field.

- Math and science teachers and counselors should be invited to professional training programs and workshops designed to help educate them about the field. There is an indication it will help motivate teachers in their classrooms as well as allow them to become more competent to discuss it in their classrooms and to use it in their curricula.

- Summer college programs already being held for high school students interested in the math and science fields should be expanded across the country. These offer an excellent opportunity to generate awareness and excitement among those most likely to have an interest in the field. It would cause the field to be perceived to be "different."

- Curriculum helpers should be developed for math and science classes. These should consist of materials that would help teachers relate their curriculum to the tasks in which professionals, particularly civil engineering, are involved. This could include anything from small projects (e.g. lab projects) to replacement story problems to exercises (such as students finding out how their parents use math in their jobs). While these materials may be used to supplement current course materials, they should also be designed ideally in a way that could replace currently used less effective materials allowing them to bring this new perspective in without forcing them to cover additional issues. These are important for both science classes and math classes. The challenge is greatest in math classes where these types of tools are not currently used for the most part.

- There is an opportunity to help local civil engineers who currently make classroom or school presentations on their careers improve these efforts. This could be achieved by development of a "Guide To Interesting Career Presentations" as well as carefully developed video presentations that could be used in conjunction with these presentations.

- Recent graduates in the field should be encouraged to make presentations at schools. Many students feel they can relate to these individuals' experiences best. It is also recommended that strong mentoring programs be set up to expose minority professionals in their communities.

- While the objective of this study is not to "steal" students from one engineering discipline to another, there is opportunity to improve the ratio of students selecting civil over other engineering disciplines. By improving college students' exposure to the engineering specialties, they will be more likely to enter the field of greatest interest to them. It may also be a way to improve overall retention levels at the college level.

- Retention levels might also be improved by greater involvement of college underclassmen in engineering programs. Specifically, it is recommended that introductory classes explore the field in general as well as its specialties. It is also recommended that underclassmen be encouraged to participate in professional society events. Finally, support programs that have been developed for minorities historically could also prove effective among all students.

- Perceptual and actual barriers that restrict students from transferring into engineering from other majors should be reduced. The perception of these problems limits transfers from other majors.

Finally, this report would be remiss if it did not include the most radical and controversial of approaches to expanding the civil engineering pool. There is no question among those who are aware that civil engineering is perceived as being the lowest paying of the engineering professions. If there will be a dangerous shortage in the field in the future, then there is little doubt that increasing salaries may be required in order to attract more young people into the field. The other alternative suggested in the study was to increase the usage of para-professionals with associates or technical degrees. Many perceive these types of individuals could take over many of the less sophisticated responsibilities of the civil engineers.

What follows are the findings upon which these conclusions and recommendations have been developed.

SUMMARY OF FINDINGS

Each session began with respondents providing background on themselves including their age (or the ages of their children) and their (parents) occupations. There was a wide diversity of background in the sessions. Individuals included covered the range from lower- middle to upper-middle socio-economic class backgrounds and single and dual parent families.

Attitudes Toward Math and Science

The discussions began in earnest with respondent comment on the types of classes that were enjoyed. Of course, all the respondents had been screened prior to being invited to participate in the study to insure

that they were not totally negative toward math and science classes. In fact, in order to qualify they had to have expressed some interest in math or science curricula. Notwithstanding this however, only a handful specifically indicated that math was among their favorite classes. A few more than that liked science.

What quickly became apparent was that there was no consistent pattern in terms of the classes they did or did not enjoy. At most, respondents tended to have favorable feelings only toward specific classes (e.g. geometry versus algebra) and specific teachers. It was very common for students to make comments of the following kind, "I hate math this year, but I really liked it last year."

These essentially "non-positive" attitudes were nurtured by a combination of concern with the subject matter and perceived problems with the personality and teaching skills of their teachers. Some of the students who indicated they inherently liked some of the science and math classes rationalized this because they saw them as being like a puzzle that need to be solved. "Math is kind of like a jigsaw puzzle. I really like the challenge of trying to solve problems."

At a more basic level, some preferred math and some science classes because they perceived them to be more concrete than many of their other subjects. "I like math because there is a right and wrong way of doing things. With English everything is fuzzy. You never know what's right or wrong."

While these subject oriented issues affected their feelings about different classes, it was very apparent that the teacher is the primary influence on student attitudes toward subjects. The degree to which the teacher can motivate a class through either his or her own enthusiasm and unique teaching approaches clearly affects how they enjoy a class.

- It seems like all math teachers are carved out of stone. They never have any expression or sense of humor."
- "It's like my math teacher reads out of a book and when we ask for an explanation, he just reads it again."
- "I am not sure that my math teacher understands the subject much better than we do."

A number of specific issues were raised regarding math classes in particular. At the forefront was a problem which has plagued non-math motivated students from time immemorial -- lack of understanding for the relevance of mathematics to their present and future life. In each session students unanimously exclaimed they had badgered their teachers many times, "This seems stupid! I can't see how I would ever use this in real life."

While mathematics may be viewed favorably for its concrete characteristics, it is at the same time viewed as fuzzy in terms of its relevance to real life. Most indicated that their teachers gave inadequate responses to such inquiries -- "It's just something you have to learn." "You will need it in other math classes." This type of answer does little to explain value to students nor to help motivate them.

Some teachers and parents also attempt to explain the value of mathematics by its use in everyday life. "You need to be able to count money out at the store and make sure you get enough change don't you?" This very basic approach seemed to be used with some younger children and in lower socio-economic class environments. Although this approach may motivate students to become proficient in the very basics of arithmetic, it does not work well in creating interest in more complex mathematics courses.

Only a handful of students in the entire study were able to provide examples of how their teachers had answered this question more effectively.

- One described a teacher who required students to write a short paper describing how their parents used math in their jobs. This relatively simple exercise intrigued many of the students. It caused them to look at the subject more intensively -- less cursorily than the approach used by many teachers.
- Another math teacher had students interview an unrelated adult professional and provide a similar type of report.
- Two students indicated they had teachers who had charts that described which professions required heavy use of their subjects. This appeared to generate interest in most of the students. It was primarily left up to them, though, to use this resource on their own. The teacher did not build it into the curriculum.
- Some teachers and students indicated that newer math books included pages interspersed throughout the book that describe how some professions use mathematics. Unfortunately, both teachers and students indicated that these were never really discussed in the classroom and that the students skipped this because they were not specifically asked to study it.
- Some suggested that story problems provide examples of how math is used. While some students and teachers agreed with this inherent idea, there were two basic problems identified.
- Some complained, "Story problems only explain how math is used in the real world if counting apples and oranges is your job."
- Even more fundamentally some complained, "Yeah, word problems could do that, but the ones in the books are not very relevant to students. Many deal with silly situations."
- And perhaps most importantly, "While they keep updating the math books for new teaching techniques and they have inserted some

career pages, I don't think they have ever updated the word problems. They are still back in the 1950's."

During the course of the discussions students and teachers were presented with the concept of word problems relating specifically to a situation an individual in a specific career might have to solve. For example, a structural engineer was designing a building... This intrigued all of them. It would show the relevance of math. It would make some of the problems more interesting. It would also educate them on what some different careers involved.

Aside from the relevance issue, there were real problems raised by both students and their parents about what appeared to be the motivation and qualifications of most of their math teachers. Several adults specifically raised the following kind of question, "Are math teachers given enough training in college to teach math?" Others questioned "How many math teachers are really math teachers rather than converted from other subjects?" or that their kids "had the football coach teaching their math class."

The few students who indicated they had truly motivated math teachers were the ones who really seemed to enjoy their math classes. In fact, they were motivated to take more math classes and even to go into math related careers. Those teachers attempted to make the subject more interesting, varied their teaching approaches and showed concern with students learning the subject.

Many students indicated that not all math teachers are bad. More often they felt that some years they have good math teachers and other years they have bad math teachers. Their perception was that in those years that they had a bad math teacher, they did not learn as much. Several students indicated this caused a major stumbling block. "It seems like every year math builds on what you learned the previous year. If you have a bad teacher one year you end up in trouble the next year because you don't know the stuff from the year before well enough. You can never catch up!"

While some of this same class of problems was also prevalent in science classes, it was not quite as big an issue. Science classes often involve more of the hands-on types of activities which the students enjoy. There did not seem to be quite the same problem of inconsistent quality of teachers in science departments. Nor was there as much concern over the relevancy of the subject matter!

Interest in math and science was also stimulated through hands-on projects -- the most notable being science fairs. Many students both enjoyed and were motivated by the opportunities this offered to research and to apply their knowledge in creative ways. One teacher described a student who eventually became a civil engineer because of a project he undertook in junior high school designing a straw bridge.

Both students and parents were asked about the degree to which specific subjects were encouraged at home more heavily than others. Most indicated they stressed all subjects equally. Parents tended to stress those subjects that their children are having trouble with more heavily in order to encourage them to improve. While some indicated they felt math and science were particularly important, most felt it was even more important for their children to have a "well rounded" education.

There was clearly a problem with parents' ability to help their children in math and science classes. While they could encourage their children to study or seek help in math and science classes, many felt they did not have the ability required to help their kids themselves. This was especially a problem in lower-middle class households. The higher the social class, the more likely that at least one of the parents would have some strengths in math or science to help their children. A number of parents exclaimed "Oh, my husband helps with math. I'm better at English."

In lower socio-economic households it was less likely that anyone would be able to provide adequate help due to time and education constraints. "I work long hours. I never seem to have the time to help, but I encourage my kids to study." "I never finished school myself." Moreover, math classes in particular tended to require more homework time than other classes. This caused problems in some lower socio-economic homes where the students either worked or helped their parents out with their siblings.

As students enter high school they indicated they become more aware of the impact of their course work on their future lives. This transition is partially stimulated by their academic counselors who begin to direct them toward a college preparatory course track. It is at that time that they are shown the types of courses they must take. They believe they are given relatively little opportunity to select electives. The only true options that may or may not be available to them are honors or advanced placement courses or more fundamental classes aside from the main track.

Their track selection is determined predominantly on whether they intend to go to college with little if any emphasis being placed on potential academic or professional career interests. Therefore a student with strong interests in a career involving math or science is frequently not informed about the potential importance of taking advanced math and science classes.

This appears to be at least partially because counselors need to see far too many students. Students claim they have had as little as 10 minutes a year with their counselor to discuss their scheduling and perhaps a little time toward the end of their high school years to discuss college applications! Students, counselors, parents and teachers all recognized the limitations of the availability of counselors for any more thorough discussions in terms of careers or specific academic plans. "I once tried to get in to see a counselor, but it was a joke. I couldn't get an appointment."

Career Planning

There was a difference of opinion in terms of exactly what students ought to think about at various stages of their schooling. Some parents believed that their children should have as general an education as they can for as long as possible. This, they felt, was important in order to develop into a well-rounded person. They did not want their children to become too career oriented at too young an age. They thought, among other things, that they would lose too much of their youth if this occurred. Similarly, many counselors believed that it is far more important for students to think about which college they were going to attend (a counselor's primary responsibility) than worrying more specifically about what their major might be and their future career.

On the other hand, those actually involved in engineering at the college level, both the professors and the students, indicated that if you wanted to become an engineer, you needed to know that well before you entered college! Certainly, if you did not begin as an engineering major when a new freshman, it would be difficult and, in some cases, nearly impossible to graduate as an engineer in four years due to the rigors of the curriculum. Some even felt that transfers into the engineering program were discouraged.

There is a clear pattern in students' development of their career interests. During elementary school, they had very little specific academic interests -- although they were occasionally turned on by subjects to which they were exposed either in the classroom or at home. It was not uncommon for children at this age to become truly enamored of things in their environment. Some parents gave examples of their kids -- such as one who "loved his fish tank and then wanted to become a marine biologist."

Similarly, they also developed interests in fields to which they are exposed by their parents, siblings, relatives and friends of the family. "Dad had a friend, who was a lawyer. He was a really neat guy. It made me want to be a lawyer when I grew up."

It appears that many of the civil engineering college students had some previous connection with the field whether through family or previous work experience. Several of the practicing civil engineers who participated indicated their child had or was entering the profession. Similarly, many of the students had siblings, cousins or friends of the family in the field. Unfortunately, respondents from lower and middle class families did not tell of such positive family influence. Furthermore, there were few, if any, female role model examples given.

As students entered junior high school, they began to be exposed to and comprehend more things in the world. These interests developed rapidly. In some schools students were given aptitude tests and participated in discussions about family life and different types of careers. These students did not appear to be ready for detailed information on careers. Most viewed "careers" as something their parents have. It is too far in their futures to be considered seriously. In fact, however, they did enjoy learning about some of the interesting jobs that different types of people have. They were highly impressionable during these years.

At this age students began to develop values for their lives. In many ways, these values seem to be more important than specific career interests. These values were often generated from experiences in their own homes.

- Money is taught to be very important. They want to be sure to make enough money to "get the things my parents always say we can't afford." Many students and parents acknowledge that the message about the importance of a good paying career is given freely, directly and often.

- Time is very important. Many want to avoid the experience they have encountered of "my parents having jobs where they are always working and never getting to spend time with us kids."

- Some are also concerned with stress. They see how stressful some of their parents jobs can be and want to avoid that pitfall.

- Another very important fundamental value is their concern that a job not be monotonous. They very much want something which is perceived as exciting based on the types of activities they would be involved in and the issues with which they would deal.

As they entered high school, they began to be exposed to more direct stimuli; career days, college preparatory decisions and more advanced subjects. Later in high school they began to realize they must make some decisions about whether they want to go to college at all and, to some degree, what they might study there. While some counselors encouraged students to consider careers paths in selecting colleges and majors, there is little evidence that real discussion occurred nor was there any real counseling. Even at this age, many had a hard time thinking seriously about where they are going to be later in their lives. "I mainly like to play sports and listen to music. I'm not really into working or anything like that." Many reluctantly recognized the need to begin thinking about it. "I guess I should start thinking about it, but it's just not a priority right now."

When students were asked to discuss specifically what they were looking for in a career, they usually focused on a single factor -- money. It was very important to all the participants that they get a really good paying job. This seemed to come both from their internal desires to better themselves and to have money to do the things they want to do as well as from messages coming from their parents over the years. Whether the parents had struggled or not, they were always trying to teach them lessons about the importance of a good paying job and the importance of education to get to that point. This message sank in very clearly. The students were very preoccupied with money. So much so that when presented with information on a career that indicated it was among the best paying for undergraduate students, they were not satisfied. "I

don't want to know that it's a good paying career. I want to know how many dollars I have coming."

Students' experience within the school system at being exposed to and having discussions about career opportunities vary greatly by school district. Most of the students were hard pressed to indicate when and in what ways they discussed career opportunities in their schools. Quite often such inquiries were met with shoulder shrugs.

Most school districts did have some form of career day or career night. These were in one of several formats ranging from an open house where they went from booth to booth and talked to people in different careers to a more formal setting where students "signed up" for three careers for which they viewed presentations. In some cases, these career days were mandated. In other cases they were optional and were viewed excitedly as "a day off from regular classes." In still other cases they were optional and held in the evening. Typically, the booths or presentations were conducted by local individuals or professional societies. Some utilized "canned" presentations, and others put their own programs together.

Generally speaking, there was very little enthusiasm for career days. While they were viewed as "A way to get out of classes for the day, they were not viewed as giving very much useful information. Many of the students complained "I signed up for career presentations, but boy, none of them sounded very interesting once I got to the presentation." There seemed to be a combination of poorly run presentations as well as careers not meeting expectations.

Beyond career days, some school districts had some sort of social science classes for students which included an effort at increasing career awareness and selection. This was particularly true in southern California where all ninth grade students took a class which included discussions of career opportunities. Once again, most of the students did not have very favorable attitudes toward their class. To some it was viewed as a study hall. Others did make use of the opportunity to learn something about careers. At the very least, it exposed students to career planning materials available in the schools.

Many of the students had gone through some form of testing to evaluate their aptitudes and interests. The most common test was the Armed Services Vocational Aptitude Battery. It tests specifically for mechanical aptitudes. Those who were college bound had very little interest. Most of the participants laughed at the thought of the test.

Some had gone through other aptitude profiling systems. Quite often they had trouble relating the results of these to the real world. They viewed the questions and methodology suspect and therefore were hesitant to accept the results. "I don't see how asking these kinds of questions has anything to do with selecting a career." One problem was a lack of explanation about the methodology and inadequate support in using the results. In general they weren't taken very seriously.

Between one-third and one-half of the school districts represented had career planning centers in their high schools. These centers included career selection advice books and pamphlets about various types of careers. They were available as a resource for investigating career opportunities, pay scales and, to some degree, descriptions of the careers. Some of the more advanced districts included computer information systems. Either these computer systems integrated aptitude tests with data bases or were used independently. The systems generated printouts providing detailed information on specific occupations, educational requirements and the opportunity outlooks. One particular capability which interested some students was the ability to review career opportunities for specific geographic locations. Some students and counselors indicated that "Not all the descriptions are all that accurate or up to date."

Some of the districts equipped with these centers required students to investigate one or two potential careers and prepare a brief write-up. While some questioned the value of this exercise, at the very least it appeared to get them all to think about careers a little more seriously than they had before. Among other issues it forced them to think about the parameters that might be important to them in selecting a career. There was some indication that many of the districts that had these centers had either very little staffing to help them make use of it, or relatively little encouragement to make use of it. Relatively few students seemed to make significant use of it on their own. There is clearly interest encountered from a number of directions to consider different careers. Throughout their lives most of the students and parents indicated that they discussed different careers regularly, either in their homes or with their friends. Quite often this was based on things they were exposed to either in a class or in everyday life. Many of the students indicated that a lot of their career interest came from "Things I see on T.V." The legal, medical and various other professions were glamorized by numerous television shows. These specialized T.V. shows and movies had a big impact on creating awareness and interest in certain careers. Several respondents astutely commented that "there are so many good careers that do not get this kind of publicity."

There was also limited exposure to careers in the classroom. In early education, parents came in and gave presentations on their occupations. Teachers exposed their students to as many different fields as possible in this manor. It should be noted though that with these types of presentations it appeared that there was tremendous bias by social class. In upper middle class school districts parents had careers such as doctors, lawyers and other professionals. Further down the social stratum very few of these types of professions were represented. Therefore, these students had less opportunity to be exposed to as many different types of career opportunities.

Some teachers also incorporated information on careers into their curriculum. This was most common in science classes where there is a very natural and easy association. It was done in a very limited fashion, as discussed previously, in math classes. Many of the math

te. ers in particular did not seem well equipped to talk about careers involving math. Most students (and parents) believed they were teachers certified in math rather than individuals familiar with mathematical applications. They did not appear to be very familiar with the subject matter themselves! A few teachers and counselors indicated they had participated in university sponsored programs to educate them on math and science related fields. They enjoyed both the attention given to them and the value of the information.

While there was interest in utilizing prepared materials on careers in their classes, there was also hesitation. Teachers felt they are already pushed to the limit in terms of the amount of material they must present in their classes. Several teachers exclaimed, "Any additional materials would have to replace existing materials on specific subjects. I just cannot add anything to my lesson plans."

Along the same lines, many top math and science students were given the opportunity to participate in summer programs which exposed them to math and science fields, particularly engineering. These programs were often conducted on local college campuses which had strong engineering programs. These students were brought in for one to two weeks where they had both classroom and laboratory experiences. Students who participated in these programs thoroughly enjoyed them. They found them challenging, rewarding and stimulating. These students clearly had their interest in engineering fields heightened.

There were several types of these programs offered. Some were designed for the general population and some programs were specifically targeted at women and minority students. The minority programs in particular appeared to do a very good job. There was an indication that they helped minority students with a strong math and science background learn about the engineering field as well as gain confidence in their ability to succeed in the profession. It appeared to offer encouragement to proceed with the education required for the profession.

Minority programs went hand in hand with a variety of other programs being offered for minority students. There were a number of programs that attempted to support minorities in school, to encourage them to continue their academics and to provide them with the life and work skills required to succeed. In particular, there was an attempt to provide confidence in themselves and their ability to integrate into society. These programs exposed them to a variety of successful minority role models. It exposed them to a number of different careers that they might not have experienced on their own. The students who participated in these programs appeared to be extremely self-confident, motivated and capable. The programs available for minority students at the high school and college level prepared them to work together as a team appeared to have a very positive influence on their success rates.

Some students, quite often the best students, are given advice during the course of their education on possible career paths. This occurs particularly with students who are leaders and who stand out in the classroom. It is particularly true for those who develop a relationship with a teacher. Some teachers suggest career paths in chatting with these students.

Again, this is more common among those who were strong in math and science. They were told time and time again that since they were good in math and science, they should consider going into engineering. While this encouragement was given, for the most part very few were ever fully apprised of what the field of engineering was all about. Nor were they specifically encouraged to go out and research the subject to learn about the field. The outcome of this was apparent among top college students who indicated they entered college with a declared major of engineering only to ask on the first day of classes, "Can someone please explain to me what an engineer really does?"

This fundamental lack of understanding is not for total lack of research. Some had looked through college catalogs or even read career outlook materials on the field of engineering. Some of these individuals knew there were different fields of engineering such as chemical, mechanical, electrical and even civil engineering. But they had little sense of what an engineer really did and had even less sense of what the specific fields' areas of responsibility actually included.

Some college students indicated they changed majors several times while in college. To a large part this was due to their confusion over the field of engineering and how curricula were set up. Some left the major altogether while others switched specialties several times. Part of this was caused by the fact that some schools did not have an introductory course which explained the field and the different specialties. Thus they floated between majors until they eventually found one with which they were happy.

Along the same lines many engineering programs did not have students taking classes in their field until their junior year. The first two years consisted of outside requirements specifically in the fields of math and science. This caused problems for several reasons.

- Students never felt as if they were a part of the engineering school. They were not encouraged to join professional societies. Many indicated they felt isolated -- "I was working real hard toward a goal shared by many others, but we had not really met. We could not share in our agony."

- Many also complained that they experienced the same problems they had in their earlier education. They took courses that were difficult but the coursework did not necessarily relate directly to their field. While the math and science classes would eventually become important, they were not focused in a way that motivated them to really want to work at the subject.

- As mentioned previously, many entered college without a clear understanding of engineering. Some had difficulty justifying the

rigorous background curriculum when they did not understand the field and were not positive it was what they wanted.

Some universities did include introductory engineering classes taken by incoming freshman. Students in these programs seem to be somewhat better adjusted and more directed.

Attitudes Toward Careers

When the discussion turned to more specific career paths, there was very little awareness beyond superficial images. The only exceptions were those fields which were highly publicized through the media. Even with these, it was not clear they had an accurate understanding of the career. Their understanding was at a very basic level. "I've heard business is a good field to get into." Yet there was very little understanding of what business really was, what the different specialties were and what they might entail. As mentioned previously, others have indicated an awareness of engineering as being a good field but not an understanding of what being an engineer entailed.

As mentioned above, there was only limited specific awareness of the field of engineering. Most students were primarily attracted to it for its perceived use of mathematics and science and the financial opportunity it offered. Many students jokingly attempted to define an engineer as "The guy who stands at the end of the train on the railroad." While they were making a joke, their lack of knowledge was very real. For many, this was truly the full extent of their knowledge.

Those who knew about engineering had a mixture of accurate and inaccurate perceptions. Some related engineering to the drafting classes that were offered in some schools. Some felt that "Since I'm not a good drafter or a good artist, engineering isn't what I want."

This is not to say that there wasn't any awareness of the field. In each of the sessions there were individuals who were motivated by particular interests and had learned about those fields. Thus, there were some who loved computers and had decided to dedicate themselves to computer engineering. There were those who enjoyed the construction industry and wanted to be involved in it in a professional way. These typically were people who had been exposed to those various professions through a family member or teacher at some point in their lives. It might very well have been because somebody in their family worked in a construction company or because they themselves had worked on a construction site where they were exposed to a structural engineer or supervisor of some sort.

As the discussion of different professions and the field of engineering in particular progressed an attempt was made to discuss the different specific fields of engineering. It was interesting that quite often when students were asked to define the term engineering they answered, "Aren't they the people who design bridges and roads and stuff like that?" In more detailed discussions though, they were unable to place those types of activities with the correct specialties.

While there was relatively little knowledge of the specific fields of chemical, electrical, mechanical and civil engineering, an attempt was made to provide brief explanations of what each of these fields were and to gauge interest in them. In the course of this discussion, civil engineering turned out to be an enigma. When the field of civil engineering was presented, one of three responses was elicited.

- Many respondents shrugged their shoulders. They had very little idea of what it was.
- Some, particularly parents, made the association that "Aren't those the guys who work for the county and drive around in little yellow trucks?" This was not viewed as a flattering comparison. These individuals were viewed as lower level workers who did not make much money.
- Some, who were slightly more aware, thought that civil engineers were the people who built roads and bridges.

None of these descriptions came across as very flattering. Fundamentally, there was very little awareness of the field. There was also relatively little awareness as to the educational requirements for the field. While they were not sure, most logically assumed that it would require similar education to other engineering fields. Many believed that some form of advanced degree, either masters or Ph.D, would be required to work in an engineering field. This perception was partially based on their understanding that engineering in general was a well paid field and their rationalization that it must thus require an advanced degree.

There were some differences in perceptions of the educational rigors required for civil engineering versus other engineering and other fields. Most believed that all engineering fields require a very rigorous and difficult curriculum. College students across the country had several consistent perceptions about engineering students.

- They are always having to study while others party.
- They rarely dated because there were so few women in their classes.
- Some female engineering students felt there was a stigma against them among males.

Those with little knowledge of engineering fields were certain that they were all fairly similar in their requirements. Some who were more familiar with engineering thought that civil engineering was probably the easiest of the fields to get into with the possible exception of industrial engineering. There was also a belief among many that civil engineers get paid less than other engineering fields. While

engineering students in different specialties joked about some fields being easier than others, most suggested that in reality "They are probably all about as difficult as each other. It's all a matter of which specific subjects are most interesting and come easiest to an individual."

In each of the sessions either a participant or the moderator informed the rest of the group that in fact most engineering fields only required a bachelor's degree; though it couldn't hurt to have a higher degree. This surprised many of the participants. Some questioned whether an individual with a only bachelor's degree would "really get to do interesting and exciting work." Some thought that the more difficult and challenging tasks would be reserved for those with higher degrees.

Not only was there the fundamental lack of knowledge over the specific types of activities that civil engineers might be involved in, but some thought they primarily worked outdoors in the field and others thought they sat in offices. Some thought they sat at drafting boards; others thought they sat at computers. Some thought it was very low tech; some thought it was very high tech. While confusion of this sort is often reflective of individuals who have their own positive imagery of a profession, in this case it was clearly more reflective of a total lack of imagery or appeal for the profession. More often than not, an individual's imagery was opposite their preference. Specifically, the term civil engineer created very little awareness or excitement for several reasons.

- There was very little specific awareness of the field.
- The phraseology did not directly communicate the nature of the field. It at best provided a very general notion of what might be involved, and at worst is totally non-descriptive.

Because of this lack of clear cut imagery, participants had rather lukewarm interest in the field. In contrast, the component elements of the civil engineering field were also presented -- transportation, structural, construction and environmental engineering, as stand alone professions. Each of these was received more favorably. While the participants may not have been exactly sure what a transportation engineer did, they could begin to guess. "He probably does stuff with roads and bridges." They could see the potential appeal of these fields. When it was later exposed that in fact these were all specialties of the field of civil engineering, there was a lot more excitement about the field in general.

There were differing degrees of interest in each of these specific fields. There was the least interest in the field of transportation engineering. There was some question as to nature of the field. Some suggested, half in humor and half in sincerity, "Isn't that the person who works on a train?" Others understood that these were the individuals who "built bridges and roads." For the most part, this definition failed to create excitement for the specialty. Several young people exclaimed "Aren't there already more roads and bridges than people knew what to do with?" Moreover, they felt that "There isn't any challenge in building a road. People already know how to build them." They saw little need or room for innovation. Because of this they felt it would be a very boring field.

The moderator challenged the participants with a variety of tasks with which a transportation engineer might be involved. These ranged from dealing with issues such as earthquakes and other environmental impacts on transportation to litigation and transportation systems of the future. They were also presented with the notion that there are many, many ways to build a road or bridge and that the transportation engineer must select his own way and adapt it to the situation. While these created some interest, it did not create excitement. There was some question as to "how many people in the field really get involved in these more exciting issues." Moreover, there was a real question as to the career opportunities in the field; "There are so many roads and bridges already, I can't see where there would be that much demand for someone in the field in the future." Some parents even suggested that "Maybe 30 years ago this might have been a good field, but not today."

Structural engineering was perceived as a bit more interesting and challenging. It had a polarized impact on individuals -- it either turned them on or off. Quite often this field had appeal to people who also had an interest in architecture. They did not fully understand the difference between the fields. "I thought architects designed buildings." "Aren't they really just technical aides to architects?" Some of these were individuals who really enjoyed building with Legos\ when they were kids. Some were just amazed with either the creativity of buildings or the challenges they present. There was a tendency to prefer the more publicized and glamorous field of architecture. Those who were less interested in structures tended to take buildings for granted; much in the same way as roads. They did not perceive it as an exciting or high visibility type of job.

As with the other fields, construction management/engineering also had mixed reactions. It tended to be very appealing to people who had worked, or whose families had worked, in the construction field. They had exposure to these types of people and saw the opportunities. It was also appealing to those how had family in the construction business who viewed this as the type of education that would best prepare them for the family business. Others viewed construction engineering as too close to being a construction worker; it was "a dirty job in the field that they would not want as a profession."

Most were very intrigued with the field of environmental engineering. They recognized its importance to the future of society and recognized the natural opportunities this could create. Some of the specific types of projects that an environmental engineer might be involved in though, had a negative impact on some individuals. Waterways and waste treatment centers are not perceived as very glamorous. There did seem to be a clear orientation for women in particular to be attracted to this field.

The notion of visibility became a very important one during many of the sessions. It was most apparent in the discussion of structural engineering. Many who were interested in designing buildings were certain it was the architects who made most of the decisions and utilized creativity. This was because architects were promoted much more heavily in the design and building process. Civil engineers themselves indicated that the profession is unique from this perspective. They indicated that "While civil engineers are the key to success in many of the largest projects built, they very rarely ever get publicity." The civil engineers also felt that "To be a civil engineer you have to be somewhat introspective. You have to be willing and able to look at a project you have worked on and gain internal satisfaction from your role because it is rare that anyone else will ever acknowledge or even be aware of what you have accomplished."

This perspective was acknowledged by other participants who had no idea of the important role civil engineers play in society. This lack of acknowledgement partially accounts for the lack of awareness among the general public of the nature of civil engineers' work. As a matter of fact, both civil engineers and other individuals indicated that the field has usually only received recognition or publicity when there was a problem with a project. Several participants indicated that the only time they had heard of the field was "When a road collapsed because of an earthquake," or "When there was a controversy with a new bridge that was being built." Similarly, many people have negative perceptions of the Army Corps of Engineers partially due to their concentrated role in difficult or catastrophic situations. This tended to create an imagery of the civil engineer as a somewhat incompetent if not bumbling bureaucrat!

The practicing civil engineers appeared particularly upset about this imagery. They were quick to explain that when several types of engineers worked jointly on a project, typically it was the civil who took the lead. The civil had the best overall outlook and the best understanding of the other fields. This notion was surprising and impressive to students and parents.

It was also proudly mentioned by the practicing civil engineers and discussed with others that they were licensed as professional engineers. This fact was very impressive to many people -- especially parents. It gave the field both credibility and exclusivity.

There were specific discussions about the appropriateness of engineering fields in general and civil engineering fields specifically for women as well as minorities. Nearly all of the students were almost offended by the question. They did not feel there was such a thing as a field that was "inappropriate" or "uninviting" to anyone. They were very committed to the notion that "Anyone can do anything they want."

Some students felt that the greatest restriction may very well come from their parents rather than from the field itself. Some women felt their parents would object to their going into an engineering field. While this made a few of the younger students apprehensive, the older they got, the more defiant it made them feel. It reached its apex with the women who stated "I am in the field because it is exactly what my parents don't want me to do. I am going to show them."

This type of defiance was also noted among practicing female civil engineers. There was clearly the perception that there were some obstacles in the field; some from older engineers not as willing to accept women into the field and some from workers, particularly construction workers, who were not comfortable with having a woman in that type of role. These women felt that they must take on a defiant attitude. They must be hardnosed, "take a few on the chin" and continue to fight and prove themselves every single day. They did not feel particularly picked on but rather that it was just another obstacle they had to overcome.

Similar attitudes were found among minorities. A number of civil and other engineering students who had exposure to the work place found it to be bit of an uncomfortable experience. Quite often they were the only minority in their department and found very little in the way of support systems. While some found that their race or ethnic background had very little impact professionally, others did experience resentment. This was less from the perspective that they did not belong and more from the perception that they may have gotten their jobs because of their race rather than for their abilities. They felt a particular burden to prove themselves and disprove these notions.

Many civil engineering minority students expressed particular interest in the field because of their race. They felt there was a "glass ceiling" above which they could not rise in traditional organizations. They viewed the field of civil engineering as unique though for the opportunity for individuals to open their own engineering consulting firms. There was an opportunity for them to get around this glass ceiling and also to own their own companies. This strong entrepreneurial spirit was also present among many of the other participants.

These defiant attitudes were not necessarily prevalent in minority parents. In particular black parents were apprehensive about their children entering professions that have historically been closed to their race. These individuals lived through a very difficult age of African-Americans breaking down racial barriers. It was a difficult and trying time in their lives. They did not want their kids to endure these same difficulties. They were very concerned about the barriers their kids would meet. They also recognize, though, that their kids had very different, more defiant attitudes than they did. Most reluctantly accepted that this was probably the right approach to take.

The field of civil engineering had particular allure to many Hispanic-Americans. It was perceived as being a very stable field for which there would always be a need. Many of the Hispanic-American individuals we spoke with were either first or second generation and were from the lower middle to middle middle class. While they looked forward to the opportunity of a well paying career, part of their interest was

predicated on the need to help support their family. Many had lived through times of difficulty when their parents were not sure when they would work or whether they had enough money. These individuals perceived the field as offering a great deal of security.

Finally, the issue of the expected shortage of civil engineers was discussed in many of the groups. The practicing civil engineers and college professors seriously questioned whether this was reality or hype. Most of them have not seen any evidence of such a shortage. In particular, they summarize their attitudes with a single common comment, "If there is such a big shortage, then why aren't salaries for civil engineers rising with the demand?"

Some questioned whether there were any other ways of solving the shortage. Lower income parents in particular, who were used to some of their peers being "para-professionals, questioned whether you really needed college educated engineers for the civil engineer's tasks. Many felt that perhaps a 2-year, less rigorous program might be sufficient to generate engineering technicians who could do much of the work of the current civil engineer. They thought that this might be an attractive program to kids from lower and middle class families who might lack the resources for a full bachelor's degree.

(THE BRAND REPORT: APPENDIX A)

CAREER PLANNING STUDY 457-10

Market:	Pittsburgh, Pennsylvania September 25, 1990 High School Students 6:00 p.m.	Austin, Texas October 16, 1990 High School Students 6:00 p.m.	Los Angeles, CA October 29, 1990 High School Students 6:30 p.m.
	Lafayette, Indiana October 10, 1990 Junior High Students - 6:00 p.m. Parents - 8:00 p.m.	October 17, 1990 Parents - 8:00 p.m.	October 30, 1990 Parents - 6:30 p.m.

Respondent Name_____ Phone #_____

Address_____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs. I would like to ask a few questions about *(ACTUAL NAME OF CHILD/YOUR CHILDREN)*.

A) Do you or does any member of your family work for a school, university, or market research firm? *IF YES, TERMINATE*

1) In what grade is your child currently enrolled?

7th ( )

8th ( )

9th ( )

10th ( )

11th ( )

12th ( )

INTERVIEWER NOTE: DIVIDE EQUALLY BETWEEN RELEVANT GRADES BASED ON SPECIFIC GROUP COMPOSITION.

2) Based on your family's past history and what you know of your child's current interests and aptitudes, what is the likelihood that your child will attend college? Would you say she/he . . . *READ CHOICES*

Definitely will attend college ( )

Probably will attend ( )

Might or might not attend ( )

Probably will not attend ( )

Definitely will not attend college ( )

TERMINATE

3) Based on your child's current interests and aptitudes, would you expect your child to be more oriented toward . . . *READ CHOICES*

Arts and Letters related studies? ( ) *ASK QUESTION 3A*

Math and Science related studies? ( ) *SKIP TO QUESTION 4*

3A) Would you say your child is good at and/or comfortable with math and science related courses, or does your child have trouble with and/or dislike math and science classes?

Good/Like ( ) *CONTINUE*

Has Trouble/Dislikes ( ) *TERMINATE*

4) Which of the following groups best describes your family's racial background?

White/Caucasian ( )

Black ( )

Hispanic ( )

Oriental ( )

Check Group Composition

Other (Specify)_____

5) Have *(YOU/YOUR CHILD)* participated in any special programs designed to inform and prepare him/her for specific careers?

No ( ) *SKIP TO QUESTION 6*

Yes ( ) *ASK QUESTION 5A*

5A) What field/profession was that for? *DO NOT READ CHOICES*

Engineering *TERMINATE*

Other (Specify)_____

6) We are going to be conducting a group discussion among *(JUNIOR HIGH SCHOOL/HIGH SCHOOL/PARENTS OF JUNIOR HIGH/HIGH SCHOOL)* students. The purpose of this discussion is to understand their knowledge of and attitudes toward different professions and related academic course work. The results of these discussions will be used to develop new career planning programs. The session will be held on _____, 1990 at _____ p.m. in _____ Building on the campus of _____ University. We would like *(YOU/YOUR CHILD)* to join us for this discussion. In appreciation of your time *(YOU/YOUR CHILD)* will receive $_____. Can we count on *(YOU/YOUR CHILD)* attending?

7) *RECORD SEX*

Male ( )
Female ( )

CAREER PLANNING STUDY 457-10
College Students

State College, PA	Lafayette, IN	Austin, TX	Los Angeles, CA
September 26, 1990	October 11, 1990	October 16, 1990	October 30, 1990
4:00 p.m.	4:00 p.m.	8:00 p.m.	4:00 p.m.

Respondent Name_____ Phone #_____

Address_____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs. I would like to ask a few questions.

1) Are you a . . . *READ CHOICES*

Freshman ( )

Sophomore ( )

Junior ( )

Senior ( )

Divide Evenly

2) Have you declared a major?

Yes ( )

No ( )

3) What major have you or do you intend to declare at this time? *IF ENGINEERING, PROBE FOR AREA OF SPECIALIZATION.*

Civil Engineering ( ) 1/2 of Respondents

Mechanical Engineering ( )

Electrical Engineering ( ) 1/4 of Respondents

Chemical Engineering ( )

Mathematics Related Fields ( )

Non-Medical Scientific Fields ( ) 1/4 of Respondents

Other Fields *TERMINATE*

4) *ASK NON-ENGINEERING MAJORS:* Next I would like to get an idea of the degree to which you have or would consider a degree in an engineering related field. Would you . . . *READ CHOICES*

Definitely consider an engineering major	( )	
Probably	( )	
Might or might not	( )	
Probably not	( )	
Definitely not consider an engineering major	( )	*TERMINATE*

5) Which of the following groups best describes your family's racial background?

White/Caucasian	( )	
Black	( )	Check Session Make Up
Hispanic	( )	
Oriental	( )	
Other (Specify)_____		

6) We are going to be conducting a group discussion among college students. The purpose of this discussion is to understand your knowledge of and attitudes toward different professions and related academic course work. The results of these discussions will be used to develop new career planning programs. The session will be held on _____, 1990 at _____ p.m. in _____ Building on the campus of _____ University. We would like you to join us for this discussion. In appreciation of your time you will receive $25.00. Can we count on your attendance?

7) *RECORD SEX*

Male	( )
Female	( )

CAREER PLANNING STUDY 457-10

Market: State College, September 26, 1990 — College Students 4:00 p.m. ( ); Junior High/High School Teachers 7:00 p.m. ( )

Respondent Name_____ Phone #_____

Address_____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs. I would like to ask a few questions about *(ACTUAL NAME OF CHILD/YOUR CHILDREN)*.

1) What grade is your child currently in?

7th	( )
8th	( )
9th	( )
10th	( )
11th	( )
12th	( )

2) Based on your family's past history and what you know of your child's current interests and aptitudes, what is the likelihood that your child will attend college? Would you say she/he . . . *READ CHOICES*

Definitely will attend college	( )	
Probably will attend	( )	
Might or might not attend	( )	
Probably will not attend	( )	
Definitely will not attend college	( )	*TERMINATE*

3) Based on your child's current interests and aptitudes, would you expect your child to be more oriented toward . . . *READ CHOICES*

Arts and Letters related studies?	( ) *ASK QUESTION 3A*
Math and Science related studies?	( ) *SKIP TO QUESTION 4*

3A) Would you say your child is good at and/or comfortable with math and science related courses, or does your child have trouble with and/or dislike math and science classes?

Good/Like ( ) *CONTINUE*

Has Trouble/Dislikes ( ) *TERMINATE*

4) Which of the following groups best describes your family's racial background?

White/Caucasian ( )

Black ( )

Hispanic ( )

Oriental ( )

Other (Specify)_____

5) We are going to be conducting a group discussion among *(JUNIOR HIGH SCHOOL/HIGH SCHOOL/PARENTS OF JUNIOR HIGH/HIGH SCHOOL)* students. The purpose of this discussion is to understand their knowledge of and attitudes toward different professions and related academic course work. The results of these discussions will be used to develop new career planning programs. The session will be held on September 26, 1990 at 4:00 p.m. in _____ Building on the campus of Pennsylvania State University. We would like *(YOU/YOUR CHILD)* to join us for this discussion. In appreciation of your time *(YOU/YOUR CHILD)* will receive $_____. Can we count on *(YOU/YOUR CHILD)* attending?

CAREER PLANNING STUDY 457-10

Market: State College, Pennsylvania — Junior/High School Teachers
September 26, 1990 — 7:00 p.m.

Respondent Name_____ Home Phone _____

Home Address_____

School District/School_____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs. I would like to ask a few questions.

1) What subjects do you teach?

Mathematics (Specify)_____

Divided Evenly

Science (Specify)_____

2) What grade(s) do you teach?

7th	( )	10th	( )
8th	( )	11th	( )
9th	( )	12th	( )

INTERVIEWER NOTE: EVEN DISTRIBUTION OF GRADE LEVELS

3) Do you utilize any career related materials in your classroom?

Yes ( ) *SKIP TO QUESTION 4*

No ( ) *CONTINUE*

3A) Do you have any interest in utilizing these types of materials as either part of your curriculum or for stimulating your students?

No ( ) *TERMINATE*

Yes ( ) *CONTINUE*

4) We are going to be conducting a group discussion among Junior High School and High School teachers. The purpose of this discussion is to understand teacher experience and attitudes toward career related materials and related academic course work. The results of these discussions will be used to develop new career planning programs. The session will be held on September 26, 1990 at 7:00 p.m. in _____ Building on the campus of Pennsylvania State University. We would like you to join us for this discussion. In appreciation of your time you will receive $35.00. Can we count on your attendance?

CAREER PLANNING STUDY 457-10
Academic Sessions

Market: Lafayette, Indiana — October 11, 1990 — 4:00 p.m.
Los Angeles, California — October 29, 1990 — 6:30 p.m.

Respondent Name_____ Home Phone _____

Home Address_____

Academic Institution_____ Work Phone _____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs. I would like to ask a few questions.

1) In which area of engineering do you specialize?

Civil Engineering (Specify area of specialty_____)	( )	1/2 of Respondents
Electrical Engineering	( )	
Mechanical Engineering	( )	1/2 of Respondents
Chemical Engineering	( )	

2) How long have you been teaching in this field?

Less than 5 years	( )	
5 - 15 years	( )	Divided Evenly
More than 15 years	( )	

3) We are going to be conducting a group discussion among university engineering professors. The purpose of this discussion is to gain an understanding of their attitudes toward career planning programs and their experience with their students in terms of planning careers in engineering. You will be given the opportunity to observe a group discussion among students, then to participate in the discussion among your peers. The results of these discussions will be used to develop new career planning programs. The session will be held on _____, 1990 at _____ in _____ Building on the campus of _____ University. We would like you to join us for this discussion. Can we count on your attendance?

CAREER PLANNING STUDY 457-10

Market: Pittsburgh, Pennsylvania — September 25, 1990
Practicing Civil Engineers — 8:00 p.m.

Respondent Name_____ Home Phone _____

Home Address_____

Company/Agency_____ Phone _____

Hello, I am _____ working with the Brand Consulting Group and *(NAME OF ACADEMIC INSTITUTION)*. We are working on a market research investigation as part of an effort at developing career planning programs for civil engineering. I would like to ask a few questions.

1) In what area of civil engineering do you specialize?

Specify _____

INTERVIEWER NOTE: WE WOULD LIKE A MIXTURE OF INDIVIDUALS WITH DIFFERENT SPECIALTIES.

2) Are you employed by the . . . *READ CHOICES*

Private sector	( )	Divide Evenly
Public sector	( )	

3) How long have you been a practicing civil engineer?

Less than 2 years	( )	
2 - 5 years	( )	Divide Evenly
More than 5 years	( )	

4) We are going to be conducting a group discussion among civil engineers. The results of these discussions will be used to develop new programs to attract young people to the field of civil engineering. The session will be held on September 25, 1990 at 8:00 p.m. We would like you to join us for this discussion. In appreciation of your time you will receive $40.00. Can we count on your attendance?

(THE BRAND REPORT: APPENDIX B)

HIGH SCHOOL/JUNIOR HIGH SCHOOL STUDENTS CAREER DEVELOPMENT DISCUSSION GUIDE

1. Introduction and establishment of moderator/group rapport.
2. Brief introduction of respondents including:
   - Age
   - Hobbies
   - Expectations for attending college/trade school/work force.
   - Current career objectives.
   - Parental occupations.
3. Discussion of attitudes toward specific types of curricula.
   - Math classes
   - Science classes
   - Other classes
     - What do you enjoy about the classes that you like?
     - What don't you like about some classes?
4. Discussion of interest in exploring educational opportunities.
   - Amount of thought given to educational direction.
     - In terms of specific educational goals.
     - In terms of career goals.
   - Degree to which information that will provide direction is sought.
   - Reasons for seeking information.
     - Give direction to life.
     - Give educational direction.
       - For junior/high school work.
       - For college preparatory/course work.
   - The nature of the information that is sought.
     - Course work required for college entrance.
     - Course work required for career development.
5. Discussion of interest and involvement in learning about career opportunities/interests.
   - General degree of interest/activity in learning about careers.
   - Sources of information about career opportunities.
     - Family, friends, relatives.
     - Exposure in classroom.
     - Career fairs.
     - Guidance counselors.
     - Other sources.
   - Reasons for selecting certain sources of information over others.
   - Nature and value of information received from each source.
     - Pamphlets/brochures from employers.
     - Pamphlets/brochures from industry organizations.
     - Pamphlets/brochures from educational institutions.
     - Videos from similar organizations
     - Books
     - Other types of information.
   - The type of information sought about careers?
     - Very general career opportunities.
     - Specific types of activities involved in careers.
     - Potential growth opportunities in specific careers.
     - Educational requirements for specific careers.
     - Exposure to high technology.

- Potential financial opportunities.

6. Generalized discussion about broad careers.

   - Medicine
   - Accounting
   - Sales
   - Nursing
   - Engineering

   - Attractiveness of career category.
   - Knowledge of the actual characteristics of the job category.
   - Knowledge of the educational background required for the career category.

7. Detailed discussion of the field of engineering.

   - What are the specific fields? (First test unaided, then aided)
     - Electrical
     - Mechanical
     - Chemical
     - Civil
   - What types of tasks describe each field.
   - Perceptions of the required education/course work for each field.
     - Nature of class work (math/sciences).
     - Level of degree required.
     - Attractiveness/unattractiveness of the field. Why?
     - In general
     - Men vs. women.
     - Minorities

8. Detailed discussion of the field of civil engineering.

   - Gestalt imagery of civil engineers.
   - Overall favorable attributes of the field.
   - Overall unfavorable attributes of the field.
   - Evaluation of the field on key issues.
     - Specific types of activities.
     - Degree of specialization.
     - Growth potential.
     - Educational requirements.
     - Exposure to high technology.
     - Status
     - Potential financial opportunities.

9. Comparison of civil engineering to other engineering and math/science fields.

   - Overall attractiveness.
   - Opportunities.
   - Intellectual challenge.
   - Academic requirements.
   - Status.
   - Financial rewards.
   - Who it attracts.

10. Exposure to and evaluation of existing civil engineering promotional materials.

- New information/insights gained.
  - Favorable
  - Unfavorable
- What didn't it tell you about the field that it should have/that you would like to know?
- Specific issues presented that had positive or negative impacts.
  - Specific activities shown.
  - Specific specialties discussed.
  - The individuals shown.
- Attitudes toward the general format.
  - Likely to watch/read entire item.
- Ability to stimulate interest.
- Showing/discussing early career responsibilities vs. later growth potential.
- Problems associated with format.

11. Discussion of where these types of resources would be sought.
    - Library
    - Counselors
    - Teachers
    - At career fairs.
    - Other sources.
  - How this information is found.
  - Ability to view video tapes (at school vs. home).
  - Problems with availability of materials.

12. Summary discussion.

PARENTS OF JUNIOR HIGH/HIGH SCHOOL STUDENTS
CAREER DEVELOPMENT DISCUSSION GUIDE

1) Introduction and establishment of moderator/group rapport.

2) Brief introduction of respondents including:
   - Ages of children.
   - Childrens' academic orientation.
   - Parental occupations.
   - Career/academic orientation of older children.

3) Discussion of parental attitudes toward higher education.
   - Attitudes toward need for college education.
   - Attitudes toward academic planning prior to college.
     - Math classes.
     - Science classes.
     - Other classes.

4) Discussion of career/specific academic planning.
   - At what ages should children be exposed to these issues?
   - Degree to which it is discussed in the home.
     - At elementary school level.
     - At junior high school level.
     - At high school level.
   - Degree to which their children seek out information on careers.
   - Degree to which parents are involved in discussion or in seeking information about careers.

5) Discussion of where students obtain/look for information on careers.

- Family, friends, relatives.
- Exposure in classroom.
- Career fairs.
- Guidance counselors.
- College catalogs.
- Other sources.
- Value of information obtained from different sources.
- What is good about some sources?
- What is bad about some sources?
- Types of information sought.
- Market need for professions.
- Career advancement opportunities.
- Specific types of activities involved in careers.
- Educational requirements for specific careers.
  - Level of education required.
  - Types of degrees required.
  - Types of classses required.
  - Exposure to high technology.
- Potential financial opportunities.
- Differences in key selection criteria by parents vs. children.

6) Generalized discussion about broad careers.

- Medicine
- Accounting
- Sales
- Nursing
- Engineering

- Attractiveness of career category.
- Knowledge of the actual characteristics of the job category.
- Knowledge of the educational background required for the career category.

7) Detailed discussion of the field of engineering.

- What are the specific fields? (First test unaided, then aided)
  - Electrical
  - Mechanical
  - Chemical
  - Civil
- What types of tasks describe each field.
  - Working with numbers.
  - Working with things.
  - Working with people.
  - Working in an office.
  - Working outside/field.
- Perceptions of the required education/course work for each field.
  - Nature of class work (math/sciences).
  - Level of degree required.
  - Attractiveness/unattractiveness of the field. Why?
  - In general

- Men vs. women.
- Minorities

8) Detailed discussion of the field of civil engineering.
   - Gestalt imagery of civil engineers.
   - Overall favorable attributes of the field.
   - Overall unfavorable attributes of the field.
   - Evaluation of the field on key issues.
     - Specific types of activities.
       - Working with numbers.
       - Working with things.
       - Working with people.
       - Working in an office.
       - Working outside/field.
     - Degree of specialization.
     - Growth potential.
     - Educational requirements.
     - Exposure to high technology.
     - Status
     - Potential financial opportunities.

9) Comparison of civil engineering to other engineering and math/science fields.
   - Overall attractiveness.
   - Opportunities.
   - Intellectual challenge.
   - Academic requirements.
   - Status.
   - Financial rewards.
   - Who it attracts.

10) Exposure to and evaluation of existing civil engineering promotional materials.
   - New information/insights gained.
     - Favorable
     - Unfavorable
   - What didn't it tell you about the field that it should have/that you would like to know?
   - Specific issues presented that had positive or negative impacts.
     - Specific activities shown.
     - Specific specialties discussed.
     - The individuals shown.
   - Attitudes toward the general format.
     - Likely to watch/read entire item.
   - Ability to stimulate interest.
   - Showing/discussing early career responsibilities vs. later growth potential.
   - Problems associated with format.

11) Discussion of where these types of resources would be sought.
     - Library
     - Counselors
     - Teachers
     - At career fairs.
     - Other sources.
   - How this information is found.
   - Ability to view video tapes (at school vs. home).
   - Problems with availability of materials.

12) Summary discussion.

JUNIOR/HIGH SCHOOL TEACHERS
CAREER DEVELOPMENT DISCUSSION GUIDE

1) Establishment of moderator/group rapport.

2) Introduction and brief backgrounds of respondents.
   - Grades taught.
   - Classes taught.
   - Socio-economics of the school.

3) Initial discussion of role of career development in the classroom.
   - Attitudes toward its appropriateness.
     - In general.
     - For making course work more "real life".
     - For stimulating educational interest.
     - For stimulating career development.
     - Experience with using career development materials.
     - What types of classes?
     - Effectiveness.
       - Student interest.
       - Supplement to course work.
       - Repeat usage.
       - Appropriateness of materials.

4) Discussion of appropriateness for different student ages. What can, is and should be done for each age group.
   - Elementary school.
   - Junior high/middle school.
   - High school.

5) Discussion of student reactions and attitudes toward career development issues.
   - Level of interest.
   - Nature of interest.
   - Type of materials to which they respond favorably.

6) Discussion of the types of stimulus materials they have/would like to use in the classroom.
   - Real world oriented problem sets.
   - Real world case histories.
   - Career oriented brochures/video tapes.
   - Other types of materials.

7) Discussion of experience with classroom materials for specific fields.
   - Medical.
   - Legal.
   - Technical.
   - Engineering.
   - Business.
   - Other.
   - What types of materials have been used?
   - What made some better than others?
     - To the students.
     - To the teachers.

8) Discussion of teacher attitudes toward specific career opportunities.

- What fields do they believe offer the greatest opportunities for their students?
- What fields do they feel should be avoided?

9) Specific discussion of attitudes toward civil engineering as a career.
   - Gestalt reaction.
   - Favorable attitudes.
   - Unfavorable attitudes.
   - Awareness of the field.
   - Educational requirements.
   - Potential for advancement.
   - Societal need.
   - Potential compensation.
10) Exposure to and attitudes toward currently available materials.
   - Gestalt reations.
   - Favorable reactions.
   - Unfavorable reactions.
   - Appropriateness.
     - For specific grades.
     - For classroom usage.
     - For specific types of individuals.
     - Recommendations for improvement.
11) Attitudes toward appropriateness of civil engineering for specific types of individuals.
   - By social class.
   - By economic class.
   - By sex.
   - By race.

12) Summary discussion.

COLLEGE STUDENTS
CAREER DEVELOPMENT DISCUSSION GUIDE

1. Introduction and establishment of moderator/group rapport.
2. Brief introduction of respondents including:
   - Age
   - Hobbies
   - Expected major and specialty.
   - Current career objectives.
   - Parental occupations.
3. Discussion of attitudes toward specific types of curricula prior to and during college.
   - Math classes
   - Science classes
   - Other classes
     - What do you enjoy about the classes that you like?
     - What don't you like about some classes?
4. Discussion of interest in exploring educational opportunities prior to and during college.
   - Amount of thought given to educational direction.
     - In terms of specific educational goals.
     - In terms of career goals.
   - Degree to which information that will provide direction is sought.
   - Reasons for seeking information.
     - Give direction to life.
     - Give educational direction.
       - For junior/high school work.

- For college preparatory/course work.
- For selecting major.

- The nature of the information that is sought.
  - Course work required for college entrance.
  - Course work required for major.
  - Course work required for career development.

5. Discussion of interest and involvement in learning about career opportunities/interests.
   - General degree of interest/activity in learning about careers.
     - At junior/high school.
     - At college.
   - Sources of information about career opportunities.
     - Family, friends, relatives.
     - Exposure in classroom.
     - Career fairs.
     - Guidance counselors.
     - Other sources.
   - Reasons for selecting certain sources of information over others.
   - Nature and value of information received from each source.
     - Pamphlets/brochures from employers.
     - Pamphlets/brochures from industry organizations.
     - Pamphlets/brochures from educational institutions.
     - Videos from similar organizations
     - Books
     - Other types of information.
   - The type of information sought about careers?
     - Very general career opportunities.
     - Specific types of activities involved in careers.
     - Potential growth opportunities in specific careers.
     - Educational requirements for specific careers.
     - Exposure to high technology.
     - Potential financial opportunities.

6. Generalized discussion about broad careers.
   - Medicine
   - Accounting
   - Sales
   - Nursing
   - Engineering
   - Attractiveness of career category.
   - Knowledge of the actual characteristics of the job category.
   - Knowledge of the educational background required for the career category.

7. Detailed discussion of the field of engineering.
   - What are the specific fields? (First test unaided, then aided)
     - Electrical
     - Mechanical
     - Chemical
     - Civil

- What types of tasks describe each field.
- Perceptions of the required education/course work for each field.
  - Nature of class work (math/sciences).
  - Level of degree required.
  - Attractiveness/unattractiveness of the field. Why?
  - In general
  - Men vs. women.
  - Minorities

8. Detailed discussion of the field of civil engineering.
   - Gestalt imagery of civil engineers.
   - Overall favorable attributes of the field.
   - Overall unfavorable attributes of the field.
   - Evaluation of the field on key issues.
     - Specific types of activities.
     - Degree of specialization.
     - Growth potential.
     - Educational requirements.
     - Exposure to high technology.
     - Status
     - Potential financial opportunities.

9. Comparison of civil engineering to other engineering and math/science fields.
   - Overall attractiveness.
   - Opportunities.
   - Intellectual challenge.
   - Academic requirements.
   - Status.
   - Financial rewards.
   - Who it attracts.

10. Exposure to and evaluation of existing civil engineering promotional materials.
    - New information/insights gained.
      - Favorable
      - Unfavorable
    - What didn't it tell you about the field that it should have/that you would like to know?
    - Specific issues presented that had positive or negative impacts.
      - Specific activities shown.
      - Specific specialties discussed.
      - The individuals shown.
    - Attitudes toward the general format.
      - Likely to watch/read entire item.
    - Ability to stimulate interest.
    - Showing/discussing early career responsibilities vs. later growth potential.
    - Problems associated with format.

11. Discussion of where these types of resources would be sought.
    - Library
    - Counselors
    - Teachers
    - At career fairs.
    - Other sources.
    - How this information is found.
    - Ability to view video tapes (at school vs. home).
    - Problems with availability of materials.

12. Summary discussion.

CIVIL ENGINEERING COLLEGE PROFESSORS
CAREER DEVELOPMENT DISCUSSION GUIDE

1) Introduction and establishment of moderator/group rapport.

2) Introduction of participants.
   - Areas in which they teach.
   - Years in the field.

3) Initial discussion of their attitudes toward the concept of a shortage of engineers/civil engineers in the future.
   - Overall reaction.
   - Degree to which they perceive there is a problem.
   - Root cause of problem.

4) Initial discussion of what must be done to increase the pool of engineers/civil engineers.
   - Perceived changes required at high school and prior levels.
     - Changes in curriculum.
     - Changes in education about career opportunities.
     - Other changes.
     - Where these changes should come from.
       - From the school systems.
       - From the colleges.
       - From professional organizations.
   - Perceived changes required at the college level.
     - In students selecting majors.
     - In course work in majors.
     - Other.
   - Perceived changes that need to be made professionally.
   - Recruiting practices.
   - Informing the public.
   - Compensation.
   - Other.

5) Reactions to the prior discussion.
   - Attitudes toward careers.
   - Attitudes toward curriculum.
   - Attitudes toward engineering.
   - Other issues.

6) Discussion of where increases in the pool will come from.
   - By social class.
   - By economic class.
   - By sex.
   - By race.
   - Specific concerns about achieving these increases from specific groups.

7) Exposure to materials currently being used in the field of civil engineering.
   - Pamphlets/brochures from employers.
   - Pamphlets/brochures from industry organizations.
   - Pamphlets/brochures from educational institutions.
   - Videos from similar organizations
   - Books
   - Other types of information.

8) Summary discussion.

PRACTICING CIVIL ENGINEERS
CAREER DEVELOPMENT DISCUSSION GUIDE

1. Establishment of moderator/group rapport.

2. Brief introduction of the participants.
   - Areas of specialization.
   - Number of years practicing.

3. Discussion of what attracted the participants into the field of civil engineering.
   - Academic curriculum.
   - Nature of specialization.
   - Career advancement opportunities.
   - How they became aware of the field.
     - Exposure to people.
     - Exposure to promotional materials.
     - Exposure in course work.

4. Discussion of current attitudes toward the field of civil engineering.
   - Challenging.
   - Career advancement.
   - Technology.
   - Compensation.

5. Discussion of what they would tell students today about why they should consider the field of civil engineering. Probe each area for specific examples.
   - Information regarding the areas of specialization.
   - Information about actual job activities.
   - Information about interaction with technology.
   - Other information

6. Discussion of changes they believe need to be made to attract more young people into civil engineering.
   - Education about the field.
   - Academic requirements.
   - Changes in career opportunities.
   - Other issues.

7. Discussion and perceptions of who has traditionally been attracted to civil engineering and why.
   - Social class.
   - Economic class.
   - Sex.
   - Race.

8. Discussion of who is currently and who should be attracted in the future to the field of civil engineering and why.
   - Social class.
   - Economic class.
   - Sex.
   - Race.

9. Exposure to brochures and video tapes and discussion.
   - Their appeal.
   - Their accuracy.
   - Perspectives not included.
   - Perspectives that should be eliminated.

10. Summary discussion.

APPENDIX G

CANDIDATE ACTION PLANS

The purpose of this appendix is to present the details of the 15 candidate action plans. Table G-1 presents a summary of these plans, including the project title, project strategy, and target developmental stage. The ARC model argues that, for success to be achieved in enhancing the civil engineering pipeline, awareness, retention, and curriculum issues spanning the pre-college and college developmental stages must be considered. Following this model, a recommended candidate action plan was developed to essentially address each issue at each defined developmental stage (elementary, junior high school, senior high school, and college).

The candidate action plans at the college of engineering level (short-term efforts) are included to address the reality that many students currently entering college have no awareness or a very poor awareness of the engineering profession. If the ARC model is implemented, the awareness, retention, and curriculum strategies applied at the pre-college developmental stages should diminish the need for the college of engineering actions.

Each candidate action plan is organized in a four-page format. The goal, specific objectives, and target audience of the plan are presented on the first page. The target audience may include the pipeline constituents or their influencers, if appropriate. The elements of the plan, both essential and supportive, are presented on the second page. The third page of the plan describes the implementation issues, including a description of how to implement, the resources required, and suggested responsible parties. Finally, the fourth page includes the justification of the plan based on the findings of the market research and data collection. Related activities, including those being performed by other engineering disciplines or other professions, are also listed on the fourth page of each action plan.

The action plans conclude this appendix and serve as the intended product of the initial phases of this research.

Table G-1. Summary of the candidate action plans.

Project No.	Project Title	Strategy	Developmental Stage	Page No.
ARC-1	National Information Clearinghouse for Elementary Schools on Careers in Engineering	Awareness	Elementary	G-4
ARC-2	Engineer Role Models for Elementary Schools	Retention	Elementary	G-8
ARC-3	Engineering Modules for Elementary School Mathematics and Science Classes	Curriculum	Elementary	G-12
ARC-4	National Information Clearinghouse for Junior High Schools on Careers in Engineering	Awareness	Junior High	G-16
ARC-5	Engineer Role Models for Junior High Schools	Retention	Junior High	G-20
ARC-6	Engineering and Civil Engineering Modules for Junior High School Mathematics and Science Classes	Curriculum	Junior High	G-24
ARC-7	National Information Clearinghouse for High Schools on Careers in Civil Engineering	Awareness	Senior High	G-28
ARC-8	Engineer Role Models for High Schools	Retention	Senior High	G-32
ARC-9	Civil Engineering Modules for High School Mathematics and Science Classes	Curriculum	Senior High	G-36
ARC-10	National Information Center on Careers in Engineering and Civil Engineering	Awareness	College (Engr.)	G-40
ARC-11	Civil Engineering Students Retention Program	Retention	College (Engr.)	G-44
ARC-12	Engineering Across the Curriculum	Curriculum	College (Engr.)	G-48
ARC-13	National Information Center on Careers in Engineering	Awareness	College (CE)	G-52
ARC-14	Engineering Students Retention Program	Retention	College (CE)	G-56
ARC-15	Project and Design Applications in Civil Engineering	Curriculum	College (CE)	G-60

ELEMENTARY SCHOOLS

Project

ARC-1: National Information Clearinghouse for Elementary Schools on Careers in Engineering

Goal

Increase the ***awareness*** of elementary school students, their parents, and teachers, of how ***mathematics and science*** are used in engineering.

Specific Objectives

1. Enhance the ***image*** and promote an ***awareness*** of the ***engineering profession*** to students, parents, teachers, and counselors.
2. Instill a sense of excitement in mathematics and science.
3. Provide ***materials*** for use by individuals or groups to supplement retention and curriculum strategies.

Target Audience

Students:

⇒ Elementary school students (grades K-6).
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Essential Elements

- Materials should be informational and ***demonstrate*** the linkage between mathematics/science and technology.
- Information should incorporate the ***diversity*** of the engineering profession. Materials should be developed to specifically appeal to underrepresented groups (ethnic minorities and women).
- Materials developed should appeal to the student and/or influencer groups.
- Information should provide guidance on available intervention (retention) efforts and available engineering enrichment programs.

Supportive Elements

- Support of private and public science and technology organizations to encourage appropriate members to participate in these outreach activities.
- Willingness of elementary school administrators to permit representatives of the science and technology professions to visit the schools to speak with the students or teachers and to permit their mathematics and science teachers to participate in workshop/seminars.
- Willingness of science and technology professionals, especially those who are members of underrepresented groups, to act as role models by participating in the outreach activities.
- Willingness of mathematics and science intervention and enrichment program sponsors to permit science and technology professionals to visit with their participating students or to distribute science and technology materials.
- Willingness of parents to participate in special family programs with their children.

ELEMENTARY SCHOOL

Implementation

Establish a national clearinghouse to develop and distribute science and technology informational and image-enhancing materials (develop a promotional/marketing strategy). Clearinghouse to also provide advisory services to local groups for the development of local materials and core training aids, and to maintain a comprehensive data base of intervention/enrichment efforts.

Distribute materials to the target audience through either direct (mail and media techniques) or indirect means. Regional or local groups, such as State highway agencies, individual colleges of science and engineering, science and engineering professional organizations, student groups, and existing intervention and enrichment programs could function as these indirect distributors. Distribution could be directly to the students through class visitation, intervention and enrichment program visitations, or though a third party, such as teachers.

Resources Required for Implementation:

Commitment of financial support to initiate and maintain the clearinghouse. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate and current.

Commitment of the science and technology leadership to actively support and encourage their organizations and other members of the profession to assist in development and distribution of the materials.

Responsible Party:

Development of the promotional strategy should have a ***national perspective*** to enhance the image of the technology and engineering professions. Therefore, organizations such as the National Society of Professional Engineers or the American Association of Engineering Societies, with assistance and support from all engineering and professional societies, are potential responsible parties. Collaborative arrangements between engineering and mathematics and science organizations should be explored to streamline the development and distribution efforts. The services of a promotional/marketing organization with a track record of developing, testing, and producing materials, especially targeted to this development stage, are strongly recommended.

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Implementation (continued)

Potential Distributors:

- ⇒ Mathematics, science, engineering student groups
- ⇒ Practicing (and retired) science and technology professionals
- ⇒ Clearinghouse staff trained to perform visitations and demonstrations
- ⇒ Elementary school teachers
- ⇒ Existing intervention and enrichment programs
- ⇒ Media and mail techniques

Justification

Market research reveals:

- ⇒ The pipeline and influencer groups have a poor understanding of engineering and the relevancy of mathematics and science.
- ⇒ Teachers are influential in instilling a sense of excitement regarding mathematics and science.
- ⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).

Related Activities

- ⇒ Vision 2000, A World in Motion--SAE International.
- ⇒ Network for Excellence in the Teaching of Science--New Jersey Institute of Technology.
- ⇒ Teacher Training--American Indian Science and Engineering Society (AISES).
- ⇒ Sunday Afternoon with Science--American Chemical Society.
- ⇒ Pre-High School Science--American Chemical Society.
- ⇒ Short Science--American Chemical Society.

ELEMENTARY SCHOOL

Project

ARC-2: Engineer Role Models for Elementary Schools

Goal

Build the ***confidence*** of the elementary school students to do mathematics and science.

Specific Objectives

1. Instill a ***linkage*** between ***mathematics and science*** and the solving of ***socio-technical problems***.
2. Provide elementary school students with appropriate ***role model*** opportunities.
3. Provide counselors, teachers, and parents with opportunities to ***interact*** with ***practicing engineers***.

Target Audience

Students:

⇒ Elementary school students.
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Essential Elements

- Individuals committed to functioning as role models for the engineering profession (especially individuals representing ethnic minorities and women).
- Training and guidance assistance for the role models.
- Willingness of elementary school and intervention program administrators to permit access to the students.

Supportive Elements

- Materials that provide accurate information regarding engineering (see Awareness strategy for elementary school students).
- Guidance material for the role models that assists them in directing students or educating teachers through intervention programs, contests, and science fairs.
- Willingness of private and public engineering organizations to sponsor open house/field trip activities.
- Mathematics/science competitions to promote creative thinking and problem solving.

ELEMENTARY SCHOOL

Implementation

This candidate action plan could be implemented on a national, regional, State, or local level. It could be as grand as a national retention campaign utilizing the services of a promotional/marketing group or as simple as a local engineering concern "adopting" the local elementary school. Whereas the awareness strategies revolve around getting the word out about engineering (image enhancement), the retention strategies involve a greater personal involvement. Therefore, the essential element of individuals committed to acting as role models/mentors to the students and as informants to the teacher is critical to success. Materials to assist the role model/mentor are important. An informational package to help the role model develop successful contacts with schools (administrators and teachers) and intervention programs is recommended.

Resources Required for Implementation:

Commitment of the engineering leadership to encourage and permit their engineers to perform the role model function.

Funding for the development of an informational package for the role models and material for distribution targeting the pipeline and influencer groups.

Support of professional organizations to encourage their university student chapters to sponsor role model projects. The support of the respective department of engineering is equally important.

Responsible Party:

Depending on the level of implementation, the following are potential responsible parties:

- Engineering professional organizations or employers of engineers.
- Engineering professional organization chapters and student chapters with support from the national office.
- Individual departments of engineering with support from the college of engineering.
- A consortium of the above groups.

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Justification

Market research reveals:

⇒ Role models are important in the career selection process (particularly true for ethnic minorities and women).

⇒ Summer and after-school activities and programs (intervention programs) are well received.

⇒ Both practicing engineers and students studying engineering are appropriate role models.

⇒ Pipeline constituents are aware of the connection between the ability to do well in mathematics and science and careers in engineering and other technology-related professions.

Related Activities

⇒ Vision 2000, A World in Motion--SAE International.

⇒ Network for Excellence in the Teaching of Science--New Jersey Institute of Technology.

⇒ Teacher Training--American Indian Science and Engineering Society (AISES).

⇒ Sunday Afternoon with Science--American Chemical Society.

⇒ Pre-High School Science--American Chemical Society.

⇒ Short Science--American Chemical Society.

⇒ Project XL--National Society of Professional Engineers.

⇒ Field trips--Rockwell International.

⇒ Family Math--University of California-Berkeley.

ELEMENTARY SCHOOL

Project

ARC-3: Engineering Modules for Elementary School Mathematics and Science Classes

Goal

Provide a learning environment that promotes the ***early relevancy*** of mathematics and science.

Specific Objectives

1. Promote the relevancy of mathematics and science.
2. Cultivate, develop, or enhance problem-solving skills.

Target Audience

Students:

⇒ Elementary school students.

Influencers:

⇒ Teachers
⇒ Parents

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Essential Elements

- Engineers (specifically civil engineers) to work with curriculum writers in the development of demonstrations highlighting the relevancy of mathematics and science.
- Packaging of these applications into convenient modules to ease their incorporation into study plans.
- Willingness of administrators and teachers to incorporate the applications into their study plans.

Supportive Elements

- A mechanism to provide guidance to and accept feedback from teachers regarding the use of the applications.

ELEMENTARY SCHOOL

Implementation

The implementation of this candidate action plan has two distinct phases. These are the development phase and the distribution phase.

The development phase involves the collaboration between engineers, curriculum writers, and educators to develop appropriate applications that show the relevancy of mathematics and science. Examples of groups to collaborate with include the National Council of Teachers of Mathematics (NCTM), The American Association for Counseling and Development, The American School Counselor Association, and The National Career Development Association. These applications should highlight the nature of socio-technical (e.g., environmental) problems the engineer encounters. The applications should challenge students to improve their problem-solving skills.

The distribution phase must cultivate personal contacts with teachers and administrators to promote integration of the applications into the work plan. The collaboration of curriculum writers on development of the applications will also assist in the distribution process. Once integrated, the distribution process must provide a mechanism to provide guidance to the teacher, accept and evaluate feedback from the applications users (teachers and students) to evaluate effectiveness and acceptability, and make appropriate revisions to the applications.

Resources Required for Implementation:

Commitment of the engineering leadership to encourage and permit their engineers to assist in the development of the applications.

Commitment of financial support for the development of the applications and to begin and maintain an organization for the distribution of the applications. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

Responsible Party:

The following are potential responsible parties:

- The engineering profession providing the means to develop and distribute applications that involve all branches of engineering. Civil engineers would involve themselves in the development of the civil engineering related applications.
- A consortium of several of the branches of engineering that would develop and distribute application materials specific to membership of the consortium.

AWARENESS | RETENTION | CURRICULUM

ELEMENTARY SCHOOL

Implementation (continued)

- A consortium of engineering organizations and mathematics and science organizations that would develop and distribute application materials specific to membership of the consortium.

Within civil engineering, ASCE, ITE, the State highway agencies, and consulting and construction firms are potential contributors to the development and distribution framework. NSPE and other engineering professional societies (such as SAE, ASME, IEEE, etc.) are also potential contributors. Interfacing with activities of other groups (such as the American Chemical Society) is also a possibility.

Justification

Market research reveals:

⇒ Students desire more practical examples in their classes that demonstrate the relevancy of mathematics and science.

⇒ Students remember those mathematics and science teachers who performed demonstrations and did not simply lecture.

⇒ Many teachers have difficulty relating their subject to the world of technology.

Related Activities

⇒ Teacher Improvement Program--Rockwell International.

⇒ "Mineral Information Institute"--Society for Mining, Metallurgy, and Exploration, Inc.

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Project

ARC-4: National Information Clearinghouse for Junior High Schools on Careers in Engineering

Goal

Increase the ***awareness*** of junior high school students, their parents, teachers, and counselors regarding career opportunities in ***engineering***.

Specific Objectives

1. Provide engineering ***career information*** to students, teachers, parents, and counselors.
2. Enhance the ***image*** and promote an ***in-depth awareness*** of the ***engineering profession***.
3. Provide ***materials*** for use by individuals or groups to supplement retention and curriculum strategies.

Target Audience

Students:

⇒ Junior high school students with mathematics, science, and problem-solving interests.
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL STUDENTS

Essential Elements

- Career information must be ***accurate*** (current) and provide the following:
  - ⇒ Definition of engineering and its disciplines
  - ⇒ Salary structure (short-term and long-term)
  - ⇒ Working environment (office and field)
  - ⇒ Advancement potential (managerial, technical, and entrepreneurial opportunities)
  - ⇒ Educational requirements
- Information must ***avoid*** perception of "selling" the profession.
- Information should stress the ***diversity*** of the civil engineering profession. Materials should be developed to specifically target underrepresented groups (ethnic minorities and women).
- Materials developed should ***target*** the pipeline and/or influencer groups.
- Information should provide ***guidance*** on sources of financial support for education, available intervention (retention) efforts, and available engineering enrichment programs.

Supportive Elements

- Support of private and public engineering organizations and colleges of engineering to sponsor open houses/field trip activities and to encourage their members to visit the junior high schools.
- Willingness of junior high school administrators to permit representatives of the civil engineering profession to visit the high schools to speak with their students and to permit their mathematics and science teachers to participate in workshops/seminars.
- Willingness of engineers, especially those who are members of underrepresented groups, to act as role models by participating in the high school visits.
- Willingness of mathematics/science/engineering intervention and enrichment program sponsors to permit engineers to visit with their participating students or to distribute engineering career materials.

JUNIOR HIGH SCHOOL

Implementation

Establish a national clearinghouse to develop and distribute engineering career guidance and image-enhancing materials (develop a promotional/marketing strategy). Clearinghouse to also provide advisory services to local groups for the development of local materials and core training aids, and to maintain a comprehensive data base of intervention efforts.

Distribute of materials to the target groups through either direct (mail and media techniques) or indirect means. Regional or local groups such as State highway agencies, individual colleges of engineering, professional organizations, student groups, and existing intervention and enrichment programs could function as these indirect distributors. Distribution could be directly to the students through career days, open houses, science and mathematics clubs, or through a third party such as teachers or guidance counselors.

Resources Required for Implementation:

Commitment of financial support to initiate and maintain the clearinghouse. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

Commitment of the engineering leadership to actively support and encourage their organizations and other members of the profession to assist in development and distribution of the materials.

Responsible Party:

Development of the promotional strategy should have a ***national perspective*** to enhance the image of the engineering profession. Therefore, organizations such as the National Society of Professional Engineers or the American Association of Engineering Societies, with assistance and support from all engineering and professional societies, are potential responsible parties. The services of a promotional/marketing organization with a track record of developing, testing, and producing materials, especially targeted to this development stage, are strongly recommended.

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Implementation (continued)

Potential Distributors:

- ⇒ Engineering society student chapters
- ⇒ Practicing engineers; retired engineers
- ⇒ Engineering faculty
- ⇒ Junior high school teachers and counselors
- ⇒ Existing intervention programs targeting women and ethnic minorities
- ⇒ Media, mail, and electronic bulletin board techniques

Justification

Market research reveals:

- ⇒ The pipeline and influencer groups have a poor understanding of the civil engineering profession and engineering in general.
- ⇒ Junior high school is the time when general career decisions are made with input from the influencers (parents, teachers, counselors).
- ⇒ There is a perception that to be successful in engineering, a person must be in the top of the class in mathematics and science.
- ⇒ Guidance counselors are an untapped resource to distribute career opportunity materials.
- ⇒ Teachers are influential in steering a student towards a career.
- ⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).

Related Activities

- ⇒ Intervention Program--Mathematics, Engineering, Science Achievement (MESA).
- ⇒ Vision 2000--SAE International.
- ⇒ "Discover E"--National Society of Professional Engineers (NSPE).
- ⇒ "Project XL"--NSPE.
- ⇒ MathCounts--NSPE.
- ⇒ Students Engaged in Engineering--American Consulting Engineers Council.

JUNIOR HIGH SCHOOL

Project

ARC-5: Engineer Role Models for Junior High Schools

Goal

Maintain the ***confidence*** of junior high school students to do mathematics and science and promote ***interest*** in technology with emphasis on engineering.

Specific Objectives

1. Provide a ***linkage*** between ***mathematics and science*** and the solving of ***socio-technical problems***.
2. Provide engineering-inclined junior high school students with appropriate ***mentor/role model*** opportunities.
3. Provide counselors, teachers, and parents with opportunities to ***interact*** with ***practicing engineers***.

Target Audience

Students:

⇒ Junior high school students with mathematics, science, and problem-solving interests.
⇒ Women and ethic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Essential Elements

- Individuals committed to functioning as role models/mentors for the engineering profession (especially individuals representing ethnic minorities and women).
- Training and guidance assistance for the role models and mentors.
- Willingness of high school and intervention program administrators to permit access to those students interested in engineering.

Supportive Elements

- Materials that provide accurate career information regarding engineering (see Awareness strategy for junior high school students).
- Guidance material for the role model/mentors that assists them in directing students or educating counselors regarding employment, scholarship, financial aid, intervention programs, contests, and science fairs.
- Willingness of private and public engineering organizations to sponsor open house/field trip activities.
- Mathematics/science competitions to promote creative thinking and problem solving.

JUNIOR HIGH SCHOOL

Implementation

This candidate action plan could be implemented on a national, regional, State, or local level. It could be as grand as a national retention campaign utilizing the services of a promotional/marketing group or as simple as a local engineering concern "adopting" the local high school. Whereas the awareness strategies revolve around getting the word out about engineering (image enhancement), the retention strategies involve a greater personal involvement. Therefore, the essential element of individuals committed to acting as role models/mentors to the students and as informants to the teacher and guidance counselor is critical to success. Materials to assist the role model/mentor are important. An informational package to help the role model/mentor develop successful contacts with schools (administrators, teachers, and counselors) and intervention programs is recommended.

Resources Required for Implementation:

Commitment of the engineering leadership to encourage and permit their engineers to perform the role model/mentor function.

Funding for the development of an informational package for the role model/mentors and material for distribution targeting the pipeline and influencer groups.

Support of professional organizations to encourage their university student chapters to sponsor role model/mentor projects. The support of the respective department of engineering is equally important.

Responsible Party:

Depending on the level of implementation, the following are potential responsible parties:

- Engineering professional organizations or employers of engineers.
- Engineering professional organization chapters and student chapters with support from the national office.
- Individual departments of engineering with support from the college of engineering.
- A consortium of the above groups.

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Justification

Market research reveals:

⇒ Role models are important in the career selection process (particularly true for ethnic minorities and women).

⇒ Summer and after-school activities and programs (intervention programs) are well received.

⇒ There is a misperception among students and their influencers regarding the requirements to study engineering and the type of work performed by the engineer.

⇒ Both practicing engineers and students studying engineering are appropriate role models.

⇒ High school guidance programs concentrate on college selection and admission and not career selection.

Related Activities

⇒ "Tests of Engineering Aptitude, Math, and Sciences" and "National Engineering Aptitude Search" Junior Engineering Technical Society (JETS).

⇒ "High School Math Enrichment Program"--American Indian Science and Engineering Society (AISES).

⇒ "Expanding Your Horizon"--Math/Science Network.

⇒ National Engineering Design Challenges National Society of Professional Engineers (NSPE).

⇒ The Hispanic Mother-Daughter Project--Arizona State University.

JUNIOR HIGH SCHOOL

Project

ARC-6: Engineering and Civil Engineering Modules for Junior High School Mathematics and Science Classes

Goal

Provide a learning environment that ***encourages*** the pipeline constituents to continue to ***study*** mathematics and science to ***prepare*** for engineering studies.

Specific Objectives

1. Maintain or promote the ***relevancy*** of mathematics and science to the engineering profession and to the solving of socio-technical problems.
2. Cultivate, develop, or enhance problem-solving skills.

Target Audience

Students:

⇒ Junior high school students with mathematics, science, and problem-solving interests.
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Essential Elements

- Engineers (specifically civil engineers) to work with curriculum writers in the development of applications for mathematics (geometry, algebra, trigonometry, and calculus) and science (chemistry and physics).
- Packaging of these applications into convenient modules to ease their incorporation into study plans.
- Willingness of administrators and teachers to incorporate the applications into their study plans.

Supportive Elements

- A mechanism to provide guidance to and accept feedback from teachers regarding the use of the applications.

JUNIOR HIGH SCHOOL

Implementation

The implementation of this candidate action plan has two distinct phases. These are the development phase and the distribution phase.

The development phase involves the collaboration between engineers, curriculum writers, to develop appropriate applications that show the relevancy of mathematics and science to engineering (specific applications demonstrating the relevancy to specific engineering disciplines is recommended). An example of a group to collaborate with is the National Council of Teachers of Mathematics (NCTM). These applications should highlight the nature of socio-technical (e.g., environmental) problems the engineer (especially the civil engineer) encounters. The applications should challenge students to improve their problem-solving skills.

The distribution phase must cultivate personal contacts with teachers and administrators to promote integration of the applications into the work plan. The collaboration of curriculum writers on development of the applications will also assist in the distribution process. Once integrated, the distribution process must provide a mechanism to provide guidance to the teacher, accept and evaluate feedback from the applications users (teachers and students) to evaluate effectiveness and acceptability, and make appropriate revisions to the applications.

Resources Required for Implementation:

Commitment of the engineering leadership to encourage and permit their engineers to assist in the development of the applications.

Commitment of financial support for the development of the applications and to begin and maintain an organization for the distribution of the applications. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

AWARENESS | RETENTION | CURRICULUM

JUNIOR HIGH SCHOOL

Implementation (continued)

Responsible Party:

The following are potential responsible parties:

- The engineering profession providing the means to develop and distribute applications that involve all branches of engineering. Civil engineers would involve themselves in the development of the civil engineering related applications.
- A consortium of several of the branches of engineering that would develop and distribute application materials specific to membership of the consortium.

Within civil engineering, ASCE, ITE, the State highway agencies, and consulting and construction firms are potential contributors to the development and distribution framework. NSPE and other engineering professional societies (such as SAE, ASME, IEEE, etc.) are also potential contributors.

Though direct avenues for distribution, i.e. newsletters, teacher workshops, are available. The use of the role model/mentor element of the junior high school student retention strategy would be an excellent distribution vehicle. The curriculum applications provides the role model/mentor an outreach tool to the teacher. However, it also provides the teacher with a source of contact regarding the application and the specifically the civil engineering profession.

Justification

Market research reveals:

⇒ Students desire more practical examples in their classes that demonstrate the relevancy of mathematics and science.

⇒ Students remember those mathematics and science teachers who performed demonstrations and did not simply lecture.

⇒ Many teachers have difficulty relating their subject to the world of technology.

Related Activities

⇒ "Doing Chemistry"--American Chemical Society.

⇒ "FACETS"--American Chemical Society.

SENIOR HIGH SCHOOL

Project

ARC-7: National Information Clearinghouse for High Schools on Careers in Civil Engineering

Goal

Increase the ***awareness*** of senior high school students, their parents, teachers, and counselors regarding career opportunities in ***civil engineering***.

Specific Objectives

1. Provide civil engineering ***career information*** to students, teachers, parents, and counselors.
2. Enhance the ***image*** and promote an ***in-depth awareness*** of the ***civil engineering profession***.
3. Provide ***materials*** for use by individuals or groups to supplement retention and curriculum strategies.

Target Audience

Students:

⇒ Senior high school students with mathematics, science, and problem-solving interests.
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

SENIOR HIGH SCHOOL

Essential Elements

- Career information must be ***accurate*** (current) and provide the following:
  - ⇒ Definition of civil engineering and its subdiscipline areas
  - ⇒ Salary structure (short-term and long-term)
  - ⇒ Working environment (office and field)
  - ⇒ Advancement potential (managerial, technical, and entrepreneurial opportunities)
  - ⇒ Educational requirements
- Information must ***avoid*** perception of "selling" the profession.
- Information should ***link*** the civil engineer with projects addressing socio-technical problems.
- Information should stress the ***diversity*** of the civil engineering profession. Materials should be developed to specifically target underrepresented groups (ethnic minorities and women).
- Materials developed should ***target*** the pipeline and/or influencer groups.
- Information should provide ***guidance*** on sources of financial support, describe intervention (retention) efforts, and offer sample descriptions of engineering enrichment programs.

Supportive Elements

- Support of private and public civil engineering employers and civil engineering departments to sponsor open houses/field trip activities and to encourage their members to visit the high schools.
- Willingness of high school administrators to permit representatives of the civil engineering profession to visit the high schools to speak with students, teachers, and counselors.
- Willingness of civil engineers, especially members of underrepresented groups, to act as role models by participating in the high school visits.
- Willingness of mathematics/science/engineering intervention and enrichment program sponsors to permit civil engineers to visit with their participating students or to distribute civil engineering career materials.

SENIOR HIGH SCHOOL

Implementation

Establish a national clearinghouse to develop and distribute civil engineering career guidance and image-enhancing materials (develop a promotional/marketing strategy). Clearinghouse to also provide advisory services to local groups for the development of local materials and core training aids, and to maintain a comprehensive data base of intervention efforts.

Distribute materials through either direct (mail and media techniques) or indirect means. Regional or local groups such as State highway agencies, individual departments of civil engineering, civil/transportation professional organizations, student groups, and existing intervention programs could function as these indirect distributors. Distribution could be directly to the students through career days or open houses, or through a third party, such as teachers, counselors, or university recruiters.

Resources Required for Implementation:

Commitment of financial support to initiate and maintain the clearinghouse. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate and current.

Commitment of the civil engineering leadership to actively support and encourage their organizations and members of the profession to assist in development and distribution efforts.

Responsible Party:

Development of the promotional strategy must have a ***national perspective*** to enhance the image of the civil engineering profession. Therefore, organizations such as the American Society of Civil Engineers with assistance and support from the Institute of Transportation Engineers and/or the State highway agencies are potential responsible parties. The services of a promotional/marketing organization with a track record of developing, testing, and producing materials are strongly recommended.

Potential Distributors:

- ⇒ Existing university/college recruiters
- ⇒ ASCE/ITE student chapters
- ⇒ Practicing civil engineers; retired civil engineers; civil engineering faculty
- ⇒ High school teachers and counselors
- ⇒ Existing intervention programs targeting women and ethnic minorities
- ⇒ Media, mail, and electronic bulletin board techniques

AWARENESS | RETENTION | CURRICULUM

SENIOR HIGH SCHOOL

Justification

Market research reveals:

- ⇒ The pipeline and influencer groups have a poor understanding of the civil engineering profession and engineering in general.
- ⇒ Senior high school is the time when specific career decisions are made with input from influencers (parents, teachers, counselors).
- ⇒ There is a perception that to be successful in engineering, a person must be in the top of the class in mathematics and science.
- ⇒ Guidance counselors are an untapped resource to distribute career opportunity materials.
- ⇒ Teachers are influential in steering a student towards a career.
- ⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).

Related Activities

- ⇒ Nadius Group (Proposal)--American Society of Civil Engineers (ASCE).
- ⇒ "Vision 2000"--SAE International.
- ⇒ "Discover E"--National Society of Professional Engineers (NSPE).
- ⇒ "Expanding Your Horizon"--Math/Science Network.
- ⇒ "PACTS" (in development)--American Chemical Society.

SENIOR HIGH SCHOOL

Project

ARC-8: Engineer Role Models for High Schools

Goal

Promote and ***retain the interest*** of senior high school students in ***technology*** with emphasis on ***civil engineering***.

Specific Objectives

1. Provide civil engineering inclined high school students with appropriate ***mentor/role model*** opportunities.
2. Provide counselors, teachers, and parents with opportunities to ***interact*** with ***practicing civil engineers***.
3. Provide a ***linkage*** between ***mathematics and science*** and the solving of ***socio-technical problems***.

Target Audiences

Students:

⇒ Senior high school students with mathematics, science, and problem-solving interests.
⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers
⇒ Counselors
⇒ Parents
⇒ Intervention/Enrichment programs

AWARENESS | RETENTION | CURRICULUM

SENIOR HIGH SCHOOL

Essential Elements

- Individuals committed to functioning as role models/mentors for the civil engineering profession (especially individuals representing the ethnic minority and women).
- Training and guidance assistance for the role models.
- Willingness of high school and intervention program administrators to permit access to those students interested in civil engineering and to permit their teachers to attend workshops/seminars.

Supportive Elements

- Summer employment opportunities in State highway agencies, consulting, construction, and undergraduate university research.
- Materials that provide accurate career information regarding civil engineering (see Awareness strategy for senior high school students).
- Guidance material for the role model/mentors that assists them in directing students or educating counselors regarding employment, scholarship, financial aid, intervention programs, contests, and science fairs.
- Willingness of private and public civil engineering organizations to sponsor open house/field trip activities.
- Cooperative education between high schools and universities to permit able high school students to begin their engineering studies.
- Development and presentation of civil engineering career workshops to mathematics and science teachers.
- Technology competitions to enhance problem-solving, creative thinking, teamwork, and communication skills.

SENIOR HIGH SCHOOL

Implementation

This candidate action plan could be implemented on a national, regional, State, or local level. It could be as grand as a national retention campaign utilizing the services of a promotional/marketing group or as simple as a local State highway agency office "adopting" the local high school. Whereas the awareness strategies revolve around getting the word out about civil engineering (image enhancement), the retention strategies involve a greater personal involvement. Therefore, the essential element of individuals committed to acting as role models/mentors to the students and as informants to the teacher and guidance counselor is critical to success. Materials to assist the role model/mentor are important. An informational package to help the role model/mentor develop successful contacts with schools (administrators, teachers, and counselors) and intervention programs is recommended.

Resources Required for Implementation:

Commitment of the civil engineering leadership to encourage and permit their engineers to perform the role model/mentor function.

Funding for the development of an informational package for the role model/mentors and material for distribution targeting the pipeline and influencer groups.

Support of ASCE and ITE to encourage their university student to sponsor role model/mentor chapter projects. The support of the respective department of civil engineering is equally important.

Private and public civil engineering concerns (State highway agencies, consultants, contractors, and universities) providing summer employment opportunities.

Responsible Party:

Depending on the level of implementation, the following are potential responsible parties:

- State highway agencies individually, aligned into regional entity, or as a national entities through AASHTO or a similar structure.
- ASCE and/or ITE chapters and student chapters with support from the national office.
- Departments of civil engineering with support from the college of engineering.
- A consortium of the above groups.

AWARENESS | RETENTION | CURRICULUM

SENIOR HIGH SCHOOL

Justification

Market research reveals:

⇒ Role models are important in the career selection process (particularly true for ethnic minorities and women).

⇒ Summer and after-school activities and programs (intervention programs) are well received.

⇒ Summer employment in engineering or construction related concerns are influential.

⇒ There is a misperception among students and their influencers regarding the requirements to study civil engineering and the type of work performed by the civil engineer.

⇒ Both practicing civil engineers and students studying civil engineering are appropriate role models.

⇒ High school guidance programs concentrate on college selection and admission and not career selection.

Related Activities

⇒ "Tests of Engineering Aptitude, Math, and Sciences" and "National Engineering Aptitude Search"--Junior Engineering Technical Society (JETS).

⇒ "High School Math Enrichment Program"--American Indian Science and Engineering Society (AISES).

⇒ "Expanding Your Horizon"--Math/Science Network.

⇒ National Engineering Design Challenges--National Society of Professional Engineers (NSPE).

⇒ "Adopt a High School" Program--various State highway agencies/departments of transportation.

⇒ Cooperative Education Programs--various universities.

⇒ Purdue University Pre-Freshmen and Cooperative Education (PREFACE).

SENIOR HIGH SCHOOL

Project

ARC-9: Civil Engineering Modules for High School Mathematics and Science Classes

Goal

Provide a learning environment that ***encourages*** the pipeline constituents to ***complete*** their mathematics and science requirements to ***prepare*** for engineering studies.

Specific Objectives

1. Maintain or promote the ***relevancy*** of mathematics and science to the civil engineering profession and to the solving of socio-technical problems.

2. Cultivate, develop, or enhance problem solving skills.

Target Audience

Students:

⇒ Senior high school students with mathematics, science, and problem solving interests.

⇒ Women and ethnic minority students.

Influencers:

⇒ Teachers

⇒ Counselors

⇒ Parents

AWARENESS | RETENTION | CURRICULUM

SENIOR HIGH SCHOOL

Essential Elements

- Civil engineers to work with curriculum writers and educators in the development of applications for mathematics (geometry, algebra, trigonometry, and calculus) and science (chemistry and physics).
- Packaging of these applications into convenient modules to ease their incorporation into study plans.
- Willingness of administrators and teachers to incorporate the applications into their study plan.

Supportive Elements

- A mechanism to provide guidance to and accept feedback from teachers regarding the use of the applications.

AWARENESS	RETENTION	CURRICULUM

SENIOR HIGH SCHOOL

Implementation

The implementation of this candidate action plan has two distinct phases. These are the development phase and the distribution phase.

The development phase involves the collaboration between civil engineers, curriculum writers, and educators to develop appropriate applications that show the relevancy of mathematics and science to civil engineering. Examples of groups to collaborate with includes the National Council of Teachers of Mathematics (NCTM), The American Association for Counseling and Development, The American School Counselors Association, and The National Career Development Association. These applications should highlight the nature of socio-technical problems (e.g., environmental) the civil engineer encounters. The applications should challenge students to improve their problem-solving skills.

The distribution phase must cultivate personal contacts with teachers and administrators to promote integration of the applications into the work plan. The collaboration with curriculum writers on development of the applications will also assist in the distribution process. Once integrated, the distribution process must provide a mechanism to provide guidance to the teacher, accept and evaluate feedback from the applications users (teachers and students) to evaluate effectiveness and acceptability, and make appropriate revisions to the applications.

Resources Required for Implementation:

- Commitment of the civil engineering leadership to encourage and permit their engineers to assist in the development of the applications.
- Commitment of financial support for the development of the applications and to begin and maintain an organization for the distribution of the applications. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

Responsible Party:

The following are potential responsible parties:

- The civil engineering profession providing the means to develop and distribute the applications specific to civil engineering.

AWARENESS	RETENTION	CURRICULUM

SENIOR HIGH SCHOOL

Implementation (continued)

- The engineering profession providing the means to develop and distribute applications that involve all branches of engineering. Civil engineers would involve themselves in the development of the civil engineering related applications.
- A consortium of several of the branches of engineering that would develop and distribute application materials specific to membership of the consortium.

Within civil engineering, ASCE, ITE, the State highway agencies, and consulting and construction firms are potential contributors to the development and distribution framework. NSPE and other engineering professional societies (such as SAE, ASME, IEEE, etc.) are also potential contributors.

Though direct avenues for distribution (e.g., newsletters, teacher workshops) are available, the use of the role model/mentor element of the senior high school student retention strategy would be an excellent distribution vehicle. The curriculum application provides the role model/mentor with an outreach tool to the teacher. However, it also provides the teacher with a source of contact regarding the application and specifically regarding the civil engineering profession.

Justification

Market research reveals:

⇒ Students desire more practical examples in their classes that demonstrate the relevancy of mathematics and science.

⇒ Students remember those mathematics and science teachers who performed demonstrations and did not simply lecture.

⇒ Many teachers have difficulty relating their subject to the world of technology.

Related Activities

⇒ Youth Motivation Program (YMP)--Rockwell International.

⇒ Doing Chemistry--American Chemical Society.

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Project

ARC-10: National Information Center on Careers in Engineering and Civil Engineering

Goal

Increase the ***awareness*** among engineering students, students from ***other majors***, and students at ***other*** academic ***institutions*** of career opportunities in engineering and civil engineering.

Specific Objectives

1. Provide ***career information*** to students from ***other majors*** and ***students at other institutions*** regarding the engineering profession.
2. Enhance the ***image*** and promote an ***in-depth awareness*** of the engineering and civil engineering professions.
3. Provide information to ***uninformed or misinformed students*** to permit them to reach a decision regarding engineering and civil engineering as a career alternative.

Target Audience

Students (especially individuals in their freshman year of study):

⇒ Students identifying civil engineering as their career preference.
⇒ Other engineering, undeclared engineering, and branch campus engineering students.
⇒ Other mathematics- and science-oriented students.
⇒ Students in 2-year associate engineering and 2-year liberal arts programs.
⇒ Students from other majors.
⇒ Returning adults.

AWARENESS | RETENTION | CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Essential Elements

- Information must be ***accurate*** (current) and provide the following specifics:
  - ⇒ Definition of engineering and its branches
  - ⇒ Definition of civil engineering and its subdivisions
  - ⇒ Salary structure (short-term and long-term)
  - ⇒ Working environment (office and field)
  - ⇒ Advancement potential (managerial, technical, and entrepreneurial opportunities)
  - ⇒ Educational requirements
- Information must ***avoid*** perception of "selling" the profession.
- Information should stress the ***diversity*** of the engineering and the civil engineering profession. Materials should be developed specifically to ***target*** underrepresented groups (ethnic minorities and women).
- Information should provide ***guidance*** on sources of financial support for education, available intervention (retention) efforts, and engineering/civil engineering enrichment programs.

Supportive Elements

- Cooperation of the administration and faculty of the other majors to encourage students enrolled in their programs, yet not sure of their decision, to explore the engineering and civil engineering options.
- Willingness of other institutions to permit representatives of the engineering and civil engineering profession to visit the schools to speak with the students or form articulation agreements.
- Willingness of engineers and civil engineers, especially those who are members of underrepresented groups, to act as role models by participating in the college visits.

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Implementation

Engineering career guidance and image-enhancing materials will need to be developed. The individual college of engineering could develop these materials or make use of materials developed on a regional or national level. A national clearinghouse to provide advisory services to the colleges for the development of local materials and training aids, and to maintain a data base of intervention efforts, would be advisable. Such a clearinghouse would eliminate repetition in the development of these materials and would further provide uniform information regarding the engineering profession. A national clearinghouse would enable the colleges of engineering to concentrate on the development of materials specific to their organization and distribution mechanisms.

Distribution of materials to the target groups could be made through either direct (mail and media techniques) or indirect means. Regional or local groups such as State highway agencies, individual departments of engineering, professional engineering organizations, student groups, and existing intervention programs could function as indirect distributors.

Resources Required for Implementation:

Commitment of financial support to initiate and maintain the clearinghouse. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

Commitment of the engineering leadership to actively support and encourage their organizations and other members of the profession to assist in development and distribution of the materials.

Responsible Party:

Though not an essential element to implement this action plan, development of the promotional strategy should have a ***national perspective*** to enhance the image of the engineering profession. Therefore, organizations such as the National Society of Professional Engineers or the American Association of Engineering Societies, with assistance and support from all engineering and professional societies, are potential responsible parties. The services of a promotional/marketing organization with a track record of developing, testing, and producing materials are strongly recommended.

AWARENESS | RETENTION | CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Implementation (continued)

The implementation of the distribution (outreach) phases of this action plan lies with the individual colleges of engineering and departments of civil engineering. This awareness action plan is designed to reach those individuals that have no perception or a misperception of the engineering/civil engineering professions. Efforts to reach these individuals during their freshman year are strongly recommended to permit timely decision making on the part of the student. This increases the ability to schedule the appropriate classes. Changing majors in the later years of study is difficult to accomplish without delaying the graduation timetable.

Potential Distributors:

- ⇒ Tau Beta Pi student chapters through chapter meetings or functions.
- ⇒ Engineering and civil engineering faculty.
- ⇒ Practicing engineers and civil engineering participating in college-sponsored activities.
- ⇒ Existing university or college intervention programs targeting women and ethnic minorities.
- ⇒ Retired engineers and civil engineers participating in college-sponsored activities.
- ⇒ Media, mail, and electronic bulletin board techniques.

Justification

Market research reveals:

- ⇒ The pipeline groups have a poor understanding of the engineering/civil engineering professions.
- ⇒ Misperception that to be successful in engineering, a person must be in the top of the class in mathematics and science.

Related Activities

- ⇒ Energizing the Green Machine--Campaign of the agriculture-related profession.
- ⇒ ASCE and ITE Student chapter activities.
- ⇒ MEP, WEP/SWE student chapter activities.

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Project

ARC-11: Engineering Students Retention Program

Goal

Retain and ***graduate*** engineering students.

Specific Objectives

1. Apply ***diversity strategy*** to general engineering population with an emphasis on women and ethnic minorities.
2. Promote a ***collaborative learning*** atmosphere for engineering students.
3. Provide a ***role model/mentor*** environment for engineering students.
4. Maximize the ***practical experience*** to be gained by civil engineering students through their educational process.

Target Audience

Students:

⇒ Engineering student population.
⇒ Women engineering students.
⇒ Ethnic minority engineering students.

AWARENESS | RETENTION | CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Essential Elements

- ***Clustering*** of the engineering students into the same classes to promote collaborative learning.
- Provision of an engineering ***study area*** to promote ***collaborative learning***.
- Provision of an ***introductory class*** to promote and retain interest in engineering and its branches (see Curriculum strategy for engineering departments).
- Strong university and college of engineering administration and faculty support and leadership.

Supportive Elements

Practical Experience Elements:

⇒ Meaningful cooperative education with public and private employers of engineers.
⇒ Meaningful summer employment opportunities with public and private employers of engineers.
⇒ Meaningful on-campus teaching and research involvement opportunities.

Financial Support Element:

⇒ Scholarships based on interest and need.

Mentoring/Role Model Elements:

⇒ Engineering professional and honor society student chapters encouraging freshman and sophomores to participate in chapter programs. These student chapters could provide ***tutoring services*** to incoming students.
⇒ ***Practicing*** (as well as retired) ***engineers*** and faculty to continually participate in college-sponsored (open house, career day, social functions) and student chapter sponsored (contests, tutoring, guidance) activities.

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Implementation

Diversity strategies targeting ethnic minorities in engineering (Minority Engineering Programs [MEP]) have been in existence for some time and provide the model for this candidate action plan. The three elements of promoting clustering, providing a study area, and providing an introductory course are considered essential for success. In implementing the plan, the individual college of engineering must determine the target group for the program. This could range from the entire engineering population to specific civil engineering subgroups (i.e., women and ethnic minorities).

It is realized that by nature, the typical engineering curriculum provides most of these elements for the general engineering population. Often, freshman and sophomore engineering students push through their engineering preparatory classes together before segregating into their selected specific branch of engineering. Engineering libraries or specific classrooms provide the study area element. An introductory/orientation engineering course is often required. For larger universities, the sheer magnitude of the number of incoming students indicating a preference to study engineering is enormous. Regardless, each college of engineering should evaluate how the three essential elements are currently being incorporated into its program and implement actions to improve its program. Promoting the clustering of students by their intended engineering branch of study is one approach. Revamping the introductory course to enhance the students' comprehension of the relevancy of their studies to practicing the profession is another approach for consideration.

Resources Required for Implementation:

- Commitment of financial support for the development and maintenance of the program. This support must be sufficient for sustaining a ***program coordinator***, development or refinement of an ***introductory course***, providing or promoting a designated ***study area***, and providing for ***research/teaching*** opportunities ***for students***.
- Strong leadership and support from the college of engineering and departments of engineering administration.
- The appointment of a coordinator responsible for implementing the program.

AWARENESS | RETENTION | CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Implementation (continued)

- Support from public and private employers of engineers to sponsor cooperative education, summer employment, and scholarship opportunities.
- Commitment of the engineering leadership to actively support and encourage their organizations and other members of the profession to continually participate in the retention activities to provide a role model/mentor element.

Responsible Party:

The implementation of this candidate action plan lies with the college of engineering. This retention strategy is designed to reach those individuals that enter the university with a desire to graduate with an engineering degree or those engineering or nonengineering students that through an awareness strategy decide to pursue engineering. Financial support will have to be provided through the university/college. Private and public employers of engineers must contribute to the plan through sponsorship of cooperative education, summer employment, and scholarship opportunities with an understanding that these opportunities should provide a role model/mentor aspect.

Justification

Market research reveals:

⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).

⇒ Intervention programs are well received by the participants.

⇒ Concern of women and ethnic minorities regarding the "chilly climate" in the workplace.

Data collection reveals:

⇒ Minority programs applying the three essential elements of clustering courses, providing a study area, and providing an introductory course have a record of success.

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Project

ARC-12: Engineering Across the Curriculum

Goal

Provide ***early*** and ***meaningful*** exposure to the engineering and civil engineering professions.

Specific Objectives

1. ***Maintain or promote interest*** in the engineering profession and the civil engineering profession.
2. Promote an ***awareness*** that engineering and civil engineering are problem-solving-oriented professions.
3. Cultivate ***problem-solving skills*** of the students.
4. Promote early ***relevancy*** of studies (technical, humanities, and communication) to the practice of engineering and civil engineering.
5. Promote a ***collaborative learning environment*** for the students.

Target Audience

Students:

⇒ The freshman/sophomore engineering student.

AWARENESS | RETENTION | CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Essential Elements

- Course content to include the following elements:
  - ⇒ Inform students of the engineering divisions.
  - ⇒ Relate divisions to solving practice-oriented/design problems.
  - ⇒ Inform students of the newer challenges facing the various engineering divisions.
  - ⇒ Emphasize the importance of the humanity and communication electives and required courses for preparing a well-rounded individual to practice engineering. Recommended electives include courses relating technology to society and operation of governmental organizations.
  - ⇒ Promote a team (collaborative) learning environment for the students.
  - ⇒ Include advice on where to turn for tutoring, career, cooperative education, summer employment, and scholarship support or information.

Supportive Elements

- Support of private and public engineering organizations and individual engineering departments to sponsor open houses/field trip activities and to encourage their members to participate in the course.
- Encouragement of practicing (or retired) engineers, especially those who are members of underrepresented groups, to participate in the course.
- Junior or senior engineering students participating in the introductory course in an active teaching role. This element would provide a role model/mentor aspect and provide the teaching assistants with practical experience.
- Prepared materials to be presented to the students on engineering career opportunities (See awareness strategy).

AWARENESS	RETENTION	CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Implementation

This action plan is intended to maintain or expand the interest and understanding of the incoming engineering student to the engineering profession, and to expose the student to the various divisions of engineering available for study. Two phases of implementation must be considered. The first phase involves the modification of the college's curriculum; specifically, developing course content and revising the other courses.

The second phase involves the actual presentation of the course. In applying this strategy, particular difficulties will have to be addressed. Specifically, how to efficiently integrate the practicing engineer from the various disciplines into the course presentation. Universities that maintain branch or satellite campuses face logistical problems to provide this introductory course.

Resources Required for Implementation:

Commitment of financial support for the development and maintenance of the course. This support must be sufficient for sustaining a course coordinator, developing the course, and providing for student teaching opportunities.

Strong leadership and support from the college of engineering and individual departments of engineering administration.

The appointment of a coordinator responsible for implementing the program.

Commitment of the engineering leadership to actively support and encourage their organizations and other members of the profession to continually participate in the retention activities to provide a role model element.

Responsible Party:

The implementation of this candidate action plan lies with the college of engineering. This curriculum action plan is designed to reach those individuals that enter the university with a desire to graduate with an engineering degree or those engineering or nonengineering students that through a broader awareness strategy decide to pursue civil engineering or gain a more in-depth understanding of the profession. Financial support will have to be provided through the university/college.

AWARENESS	RETENTION	CURRICULUM

ENGINEERING/NON-ENGINEERING STUDENTS (FRESHMAN/SOPHOMORE)

Justification

Market research reveals:

- ⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).
- ⇒ Both practicing engineers and students studying engineering are appropriate role models.
- ⇒ Misperception of the pipeline regarding the requirements to study engineering and the type of work performed by the engineer.

Data collection reveals:

- ⇒ 70 percent of white males and only 20 percent of ethnic minorities that enter college to pursue an engineering degree graduates with the degree.
- ⇒ Inadequate mathematics and science preparation, especially for ethnic minority and women groups.

Related Activities

- ⇒ Vision 2000--SAE International.
- ⇒ "Washington Internships for Students of Engineering" (WISE).
- ⇒ American Society for Engineering Education (ASEE).
- ⇒ "Airway Science Program"--The Federal Aviation Administration (FAA).
- ⇒ Engineering Education Coalitions Program--National Science Foundation (NSF).

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Project

ARC-13: National Civil Engineering Career Information Center

Goal

Increase the ***awareness*** among students identifying ***civil engineering*** as their career preference of career opportunities in the various civil engineering disciplines.

Specific Objectives

1. Provide ***career information*** regarding the various desciplines within civil engineering to students.
2. Enhance the ***image*** and promote an ***in-depth awareness*** of the civil engineering profession.
3. Provide information to ***uninformed*** or ***misinformed*** students to permit them to reach a decision regarding civil engineering as a career alternative.

Target Audience

Students (especially individuals in their freshman year of study):

⇒ The junior/senior civil engineering student.

AWARENESS | RETENTION | CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Essential Elements

- Career information must be ***accurate*** (current) and provide the following:
  - ⇒ Definition of civil engineering and its subdivisions
  - ⇒ Salary structure (short-term and long-term)
  - ⇒ Working environment (office and field)
  - ⇒ Advancement potential (managerial, technical, and entrepreneurial opportunities)
  - ⇒ Educational requirements
- Information must ***avoid*** perception of "selling" the profession.
- Information should ***link*** the civil engineer with projects addressing socio-technical problems.
- Information should stress the ***diversity*** of the civil engineering profession. Materials should be developed to specifically target underrepresented groups (ethnic minorities and women).
- Materials developed should ***target*** the pipeline and/or influencer groups.
- Information should provide ***guidance*** on sources of financial support for education, available intervention (retention) efforts, and available engineering enrichment programs.

Supportive Elements

- Willingness of other institutions to permit representatives of the civil engineering profession to visit the schools to speak with the students or form articulation agreements.
- Willingness of civil engineers, especially those who are members of underrepresented groups, to act as role models by participating in the college visits.

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Implementation

Civil engineering career guidance and image-enhancing materials will need to be developed. The individual department of civil engineering could either develop these materials or make use of materials developed on a regional or national level. A national clearinghouse to provide advisory services to the departments for the development of local materials and training aids, and to maintain a data base of intervention efforts, would be advisable. Such a clearinghouse would eliminate repetition in the development of these materials and would further provide uniform information regarding the civil engineering profession. A national clearinghouse would enable the departments of civil engineering to concentrate on the development of materials specific to their organization and distribution mechanisms.

Distribution of materials to the target groups could be made through either direct (mail and media techniques) or indirect means. Regional or local groups such as State highway agencies, individual departments of civil engineering, civil/transportation professional organizations, civil engineering student groups, and existing intervention programs could function as indirect distributors.

Resources Required for Implementation:

Commitment of financial support to initiate and maintain the clearinghouse. This support must be sufficient for material development, testing, distribution, effectiveness evaluation, and revisions to keep materials accurate.

Commitment of the civil engineering leadership to actively support and encourage their organizations and other members of the profession to assist in development and distribution of the materials.

Responsible Party:

Though not an essential element to implement this action plan, development of the promotional strategy should have a national perspective to enhance the image of the civil engineering profession. Therefore, organizations such as the American Society of Civil Engineers, with assistance and support from the Institute of Transportation Engineers and/or the State highway agencies, are potential responsible parties. The services of a promotional/marketing organization with a track record of developing, testing, and producing materials are strongly recommended.

AWARENESS | RETENTION | CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Implementatation (continued)

The implementation of the distribution (outreach) phase of this action plan lies with the individual departments of civil engineering. This awareness action plan is designed to reach those individuals that have no perception or a misperception of the civil engineering profession. Efforts to reach these individuals during their freshman year is strongly recommended to permit timely decision making on the part of the student. This increases the ability to schedule the appropriate classes. Changing majors in the later years of study is difficult to accomplish without delaying the graduation timetable.

Potential Distributors:

- ⇒ ASCE/ITE student chapters through chapter meetings or functions.
- ⇒ Civil engineering faculty.
- ⇒ Practicing civil engineers participating in department-sponsored activities.
- ⇒ Existing university intervention programs targeting women and ethnic minorities.
- ⇒ Retired civil engineers participating in department-sponsored activities.
- ⇒ Media, mail, and electronic bulletin board techniques.

Justification

Market Research reveals:

- ⇒ The pipeline groups have a poor understanding of the civil engineering profession and engineering in general.
- ⇒ Misperception that to be successful in engineering, a person must be in the top of the class in mathematics and science.

Related Activities

- ⇒ Vision 2000--SAE International.
- ⇒ Student Chapter Activities/Competitions--/American Society of Civil Engineers.
- ⇒ Student Chapter Activities--Institute of Transportation Engineers.

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Project

ARC-14: Civil Engineering Students Retention Program

Goal

Retain and ***graduate*** civil engineering students.

Specific Objectives

1. Apply ***diversity strategy*** to general civil engineering population with an emphasis on women and ethnic minorities.
2. Promote a ***collaborative learning*** atmosphere for civil engineering students.
3. Provide a ***role model/mentor*** environment for civil engineering students.
4. Maximize the ***practical experience*** to be gained by civil engineering students through their educational process.

Target Audience

Students:

⇒ Civil engineering student population.
⇒ Women civil engineering students.
⇒ Ethnic minority civil engineering students.

AWARENESS | RETENTION | CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Essential Elements

- ***Clustering*** of the civil engineering students into the same classes to promote collaborative learning.
- Provision of a civil engineering ***study area*** to promote ***collaborative learning***.
- Provision of an ***introductory class*** to promote and retain interest in civil engineering and its specialties.
- Strong department of civil engineering administration and faculty support and leadership.

Supportive Elements

Practical Experience Elements:

⇒ Meaningful cooperative education with public and private employers of civil engineers.

⇒ Meaningful summer employment opportunities with public and private employers of civil engineers.

⇒ Meaningful on-campus teaching and research involvement opportunities.

Financial Support Element:

⇒ Scholarships based on interest and need.

Mentoring/Role Model Elements:

⇒ ASCE and ITE student chapters encouraging freshman and sophomores to participate in chapter programs. ASCE and ITE student chapters sponsoring tutoring services for incoming students.

⇒ Practicing (as well as retired) civil engineers and faculty to continually participate in department-sponsored (open house, career day, social functions) and student chapter sponsored (contests, tutoring, guidance) activities.

AWARENESS	RETENTION	CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Implementation

Diversity strategies targeting ethnic minorities in engineering (Minority Engineering Programs [MEP]) have been in existence for some time and provide the model for this candidate action plan. The three elements of promoting clustering, providing a study area, and providing an introductory course are considered essential for success. In implementing the plan, the individual department of civil engineering must determine the target group for the program. This could range from the entire civil engineering population to specific civil engineering subgroups (i.e., women and ethnic minorities).

In applying this strategy, particular difficulties will have to be addressed. Specifically, it may be difficult to reach the freshman and sophomore students who have an interest in civil engineering. Often students do not declare their intentions formally until well into their general preparatory classes. Universities that maintain branch or satellite campuses face logistical problems to provide the three elements. An approach to reach the ethnic minorities and women is to interface with the college of engineering's minority engineering program and the women engineering program (if available) to identify early those students with an interest in civil engineering. Specific civil engineering activities could then supplement the broader college of engineering programs.

Resources Required for Implementation:

- Commitment of financial support for the development and maintenance of the program. This support must be sufficient for sustaining a ***program coordinator***, developing an ***introductory course***, providing a ***study area***, and providing for ***research/teaching*** opportunities ***for students***.
- Strong leadership and support from the college of engineering and department of civil engineering administration.
- The appointment of a coordinator responsible for implementing the program.
- Support from public and private employers of civil engineers to sponsor cooperative education, summer employment, and scholarship opportunities.
- Commitment of the civil engineering leadership to actively support and encourage their organizations and other members of the profession to continually participate in the retention activities to provide a role model/mentor element.

AWARENESS	RETENTION	CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Implementation (continued)

Responsible Party:

The implementation of this candidate action plan lies with the individual department of civil engineering. This retention strategy is designed to reach those individuals that enter the university with a desire to graduate with a civil engineering degree or those engineering or nonengineering students that through an awareness strategy decide to pursue civil engineering. Financial support will have to be provided through the university/college. Private and public employers of civil engineers must contribute to the plan through sponsorship of cooperative education, summer employment, and scholarship opportunities with an understanding that these opportunities should provide a role model/mentor aspect.

Justification

Market research reveals:

⇒ The importance of role models in the career selection process (particularly true for ethnic minorities and women).

⇒ Intervention programs are well received by the participants.

⇒ Concern of women and ethnic minorities regarding the "chilly climate" in the workplace.

Data collection reveals:

⇒ Minority programs applying the three essential elements of clustering courses, providing a study area, and providing an introductory course have a record of success.

⇒ 70 percent of white males and only 20 percent of ethnic minorities that enter college to pursue an engineering degree graduate with the degree.

⇒ Inadequate mathematics and science preparation especially for the ethnic minority and women groups.

Related Activities

⇒ Minority-in-engineering programs.

⇒ Women-in-engineering programs.

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Project

ARC-15: Project and Design Applications in Civil Engineering

Goal

Provide ***early*** and ***meaningful*** exposure to the project and design process of the civil engineering disciplines.

Specific Objectives

1. ***Maintain or promote interest*** in the civil engineering profession and the civil engineering divisions.
2. Promote and instill an ***awareness*** that civil engineering is a problem-solving (socio-technical) profession.
3. Cultivate ***problem-solving skills*** of the students.
4. Promote early ***relevancy*** of studies (technical, humanities, and communication) to the practice of civil engineering.
5. Promote a ***collaborative learning environment*** for the students.

Target Audience

Students:

⇒ The junior/senior civil engineering student.

AWARENESS | RETENTION | CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Essential Elements

- Applications to include the following elements:
  - ⇒ Inform students of the civil engineering divisions.
  - ⇒ Relate divisions to solving practice-oriented/design problems.
  - ⇒ Inform students of the newer challenges facing civil engineering, including IVHS, infrastructure management, and so on.
  - ⇒ Emphasize the importance of the humanity and communication electives and required courses for preparing a well-rounded individual to practice civil engineering. Recommended electives include courses relating technology to society and operation of governmental organizations.
  - ⇒ Promote a team (collaborative) learning environment for the students.
  - ⇒ Include advice on where to turn for tutoring, career, cooperative education, summer employment, and scholarship support or information.

Supportive Elements

- Support of private and public civil engineering organizations and civil engineering departments to encourage their members to participate in the development and promotion of the applications.
- Encouragement of practicing (or retired) civil engineers, especially those who are members of underrepresented groups, to participate in the delivery of the applications.
- Prepared materials to be presented to the students on civil engineering career opportunities (see Awareness strategy).

AWARENESS	RETENTION	CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Implementation

This action plan is intended to maintain or expand the civil engineering student's interest in and understanding of the civil engineering profession. Two phases of implementation must be considered. The first phase involves developing the project and design applications. The second phase involves the actual integration of the applications into the department's curriculum.

Resources Required for Implementation:

- Commitment of financial support for the development and maintenance of the applications.
- Strong leadership and support from the college of engineering and department of civil engineering administration.
- The appointment of a coordinator or committee responsible for integrating the applications.
- Commitment of the civil engineering leadership to actively support and encourage their organizations and other members of the profession to participate in the development of the applications.

Responsible Party:

The implementation of this candidate action plan lies with the department of civil engineering. This action plan is designed to reach those individuals that enter the university with a desire to graduate with a civil engineering degree. Financial support will have to be provided through the university/college.

AWARENESS	RETENTION	CURRICULUM

CIVIL ENGINEERING STUDENTS (JUNIOR/SENIOR)

Justification

Market research reveals:

⇒ Misperception of the pipeline regarding the requirements to study civil engineering and the type of work performed by the civil engineer.

Related Activities

⇒ "Airway Science Program"--The Federal Aviation Administration (FAA).

⇒ Engineering Education Coalitions Program--National Science Foundation (NSF).

Part 2—Synthesis of Current Practice

CONTENTS

Chapter **1**

INTRODUCTION

Part 2 of this report contains the annotated discussion of the various current practices, programs, and related efforts to increase interest in civil engineering, engineering in general, and other professions. It also contains an expanded section on the salient findings of the focus group sessions. A complete copy of the market research study is included for further consideration by the reader.

The purpose of this synthesis is to provide a comprehensive documentation of recent and continuing efforts of the identified contributors. Chapters 2 and 3 contain concise discussions that describe the prominent features of the programs and activities provided to the research team. The text of these chapters serves as a catalogue of efforts that agencies and academic institutions could review and secure for further development.

It must be noted that the information referenced in this report represents that which was provided to the research team based on the survey of materials as described earlier in this report. Therefore, these contents cannot be considered all-inclusive. In several locations, the authors have selected programs to demonstrate the intent or general content of the cited activity. As such, the information contained herein serves as an example of actions that were considered most relevant to the project objective. Omission of any program does not infer a lack of quality or appropriateness for the target audience of this research effort.

Chapter **2**

PRACTICES TO INCREASE INTEREST IN CIVIL ENGINEERING, ENGINEERING, AND MATHEMATICS AND SCIENCE

This chapter provides a summary of the numerous practices and programs identified in the survey of agencies, academic institutions, and related organizations. The findings have been categorized by the following efforts: highway and transportation organizations; departments of civil engineering and technology; institutions of higher education; professional and industrial organizations.

EFFORTS OF HIGHWAY AND TRANSPORTATION ORGANIZATIONS

State Highway Agencies and Departments of Transportation

Programs and Activities Practiced

A survey of all state highway agencies and departments of transportation was conducted by mail to obtain information on the programs sponsored and activities practiced with respect to increasing or maintaining interest in civil engineering, engineering, and mathematics or science. The state highway agencies and DOT's were specifically requested to forward information to the researchers regarding programs and activities targeted toward minorities and women. Forty-four of the fifty state agencies responded. A tabular summary of the programs and activities practiced by each state is presented in Appendix A.

A review of the information received revealed that the programs and practices could be categorized into one of three classifications: career information and support programs, preemployment development programs, and post-employment development programs.

The career information or support programs include a loose collection of activities and techniques used to provide career or department information to junior high school, high school, or college students. A summary of the activities and techniques identified follows: (1) *videotapes, printed materials*—includes videotapes, brochures, and pamphlets that describe the function of and career opportunities within the state highway agency or department of transportation; (2) *career days*—includes visits by agency or department personnel to high school or college-sponsored career days; (3) *open house*—allows high school or college students, as either individuals or groups, to visit and tour the various offices of the agency or department; (4) *role model or mentor*—encourages agency or department professionals to avail themselves to junior high schools, high schools, and colleges to provide a point of guidance and information to students seeking career, course selection, or employment information; (5) *contests, science fairs*—involves support or sponsorship of

contests at the high school level; (6) *support and participation in professional and resource organization activities* — includes activities sponsored by such organizations as ASCE, NSPE, and those concerned with minority and women involvement; and (7) *teacher internship program* — refers to seminars or workshops designed to educate high school teachers on the opportunities and activities of the state highway agency and department of transportation, with the intent that the teacher will relay this information to students.

The preemployment development programs are those programs directed toward college students enrolled in a civil engineering or general engineering curriculum, or toward high school students with an inclination toward engineering. These programs have both a recruitment and a retention influence on the participating students. For the state agency or department of transportation, these programs serve as tools to evaluate individuals for potential employment by the agency or the department. For the educational institution, these programs function to retain and enhance the interest of the student in the chosen career path. A summary of these activities and techniques follows: (1) *cooperative education* — involves a partnership of the state highway agency or DOT and the educational institution to permit the student to alternate between employment by the agency or department and attending classes; (2) *scholarships* — provide financial support to deserving students (several scholarship programs are directed specifically toward underrepresented groups, i.e., minorities and women); and (3) *summer employment* — provides employment within the design, construction, or maintenance department of the state highway agency or DOT for students enrolled in a civil engineering curriculum, typically those who are entering their junior or senior year of college.

The post-employment development programs are those programs designed to provide training and career guidance activities for employees of the state highway agency or DOT. These programs may have both recruitment and retention influences. For individuals contemplating employment with the state highway agency or DOT, these programs serve as an enticement to accept employment. For existing employees, these programs serve to advance the employees' education and training to continue their career development. A summary of these activities and techniques is as follows: (1) *Engineer-in-Training or Graduate Engineering Program* — Typically involves the rotation of a recent graduate engineer through the various departments of the state highway agency or DOT over a 12- to 18-month period; (2) *Tuition Reimbursement Program* — Reimburses an employee for the cost (tuition and books) of a successfully completed course offered at an institution of higher learning; (3) *Career Counseling Program* — Provides counseling services to employees regarding career opportunities and alternatives; (4) *Mentor Program* — Matches a recent graduate engineer with an experienced engineer in a mentor or protégé relation (the mentor is able to address concerns of, and provide guidance to, the protégé); (5) *In-House Training and Development Program* — Provides an opportunity for employees to complete training and development programs provided at the employee's place of work; and (6) *Advanced Degree Program* — Encourages employees to pursue an advanced degree by permitting the arrangement of a sabbatical for pursuit of studies on a full-time basis at an institution of higher education.

The frequency of practice of the foregoing programs and activities by the 44 survey respondents is given in Tables 1, 2, and 3.

With respect to the practice of career information and support programs, approximately one-half of the respondents listed the use of videotapes, printed materials, and participation in college career days as the predominant practices. Few efforts are directed toward junior high school students. Several states indicated the sponsorship of contests, open houses, and career days as active efforts directed toward high school students.

Table 1. Summary of career information and support programs administered by state highway agencies and departments of transportation.

Program or Activity		No. of Respondents
Videotapes, Printed Materials		24
Career Days	-- High School	5
	-- College	19
Field Trips/Open House	-- High School	3
	-- College	5
Role Model/Mentor	-- Junior High School	2
	-- High School	2
	-- College	0
Contests/Science Fairs	-- Junior High School	1
	-- High School	1
Professional and Resource Organizations		3
Teacher Internships		1

Table 2. Summary of preemployment development programs administered by state highway agencies and departments of transportation.

Program of Activity		No. of Respondents
Cooperative Education	-- High School	2
	-- College	18
	-- Minority Emphasis	3
Scholarships	-- General	7
	-- Minority Emphasis	2
Summer Employment	-- High School	2
	-- College	23
	-- Minority Emphasis	2

Table 3. Summary of post-employment development programs administered by state highway agencies and departments of transportation.

Program or Activity	No. of Respondents
Engineer-in-Training	23
Tuition Reimbursement	7
Career Counseling	1
Mentor Program	7
In-House Training and Development	5
Advanced Degree Program	1

Approximately one-half of the state highway agencies and DOT's responding noted that cooperative education programs with institutions of higher education, college scholarship programs, and summer employment of college students were the predominant preemployment development programs currently in place. Only a few respondents indicated the use of these programs to specifically target members of underrepresented groups.

Several state highway agencies and DOT's reported on the effectiveness of these efforts. Specifically, the Ohio Department of Transportation reported that 75 percent of recently hired engineers were enrolled in summer employment and cooperative education programs. The Kentucky Department of Highways noted that approximately 40 percent of the total engineering staff participated in the Department's college scholarship program.

With respect to the post-employment development programs, the predominant practice (as indicated by 24 of the 44 reporting agencies) is the use of some form of rotation program for recent graduate engineers. The next most predominant programs are the mentor program and tuition reimbursement, as reported by 7 of the 44 states.

Promotion of Civil Engineering, Engineering, or Mathematics and Science

The programs and activities currently in use by the state highway agencies and DOT's are presented in Appendix A. These programs and activities were reviewed to determine their primary emphasis, and whether they appeared to increase interest in civil engineering, engineering, or mathematics and science. In performing this review, it became apparent that classifying the programs by a primary emphasis is not perfect. A program designed to encourage junior high school students to study mathematics and science, for example, may have a mathematics or science emphasis on the surface. However, the encouragement — such as presentation of the material by a highway or transportation engineer from the state highway agency — may also have a role model influence upon the student toward engineering, and civil engineering specifically. Furthermore, because the state highway agencies and departments of transportation also employ individuals in professions other than engineering, some practices (e.g., open houses) often have a multidisciplinary appeal. Some examples of specific programs and activities used by state highway agencies and state DOT's are presented, as follows.

Increase interest in civil engineering — general. Summaries of several programs and activities that appear to be designed primarily to increase or maintain interest in civil engineering include: (1) *Kentucky Transportation Cabinet Scholarship Program* — for students in civil engineering at the University of Kentucky and Kentucky State University, and civil engineering technology students at Western Kentucky University. Awarded according to the student's class standing, monies are paid monthly, with the student agreeing to work for the Kentucky Department of Highways after graduation for a time equal to the duration of the scholarship. These students are also employed by the Department during the summer in the various engineering groups. (2) *Summer Internship Program* — a 9-week course for students at The Ohio State University. The class provides basic information regarding procedures used to perform construction inspection. These students are subsequently employed by the Ohio Department of Transportation as summer interns. (3) *Project BRAINSTORM* — an acronym for *B*etter *R*esults *A*chieved by *I*ntroducing *N*ew *S*trategies *T*o *O*ur *R*ecruitment/retention/outreach *M*ethods. Currently under development by the Maryland State Highway Agency, this program is envisioned to incorporate career outreach, recruitment, and retention activities into a single interactive program. The activities envisioned include most of the career information and support programs, preemployment development programs, and post-employment development programs discussed earlier.

Increase interest in civil engineering — minority emphasis. The following are summaries of several programs and activities designed to increase or maintain interest in civil engineering with an emphasis on the participation of minorities and women: (1) *High School Incentive Program (HSIP)* — sponsored by the Michigan Department of Transportation and created to encourage minority involvement in the engineering classifications within the Department. HSIP offers minority high school graduates the opportunity for on-the-job training in various areas of civil engineering. Approximately 15 students participate annually. Upon enrollment in a university program, these students are employed at a district or project field office during the academic school year. To continue in the program, the participants must declare civil engineering as their major before the completion of their junior year in college. (2) *Minority Engineering Program (MEP)* — sponsored by the Wisconsin Department of Transportation. This program provides scholarships and semester or summer employment for minority students enrolled in a civil engineering curriculum. (3) *Summer Intern Program* — sponsored by the New York State Department of Transportation. This program provides summer employment for college students with an emphasis on the participation of minorities and women.

Increase interest in engineering. The following are examples of established state highway agency and department of transportation programs and activities designed to increase or maintain interest in engineering: (1) *Field Days and Open House* — This practice varies from an individual approach to group tours. The Maryland State Highway Agency sponsors "Engineer-for-a-Day." This program pairs high school students with Agency engineers. The student gains insight into the engineering profession through this active, one-on-one approach. Other agencies and departments of transportation invite high school or college groups to tour facilities. Missouri and North Carolina sponsor open houses of their various facilities for college students. Ohio has an open house for high school students in conjunction with the NSPE-sponsored "Engineers Week." Oklahoma indicated sponsorship of open houses for both high school and college students. (2) *Cooperative Education* — While many state highway agencies and departments of transportation reported the use of cooperative education with institutions of higher learning, the Wisconsin Department of Transportation reported a cooperative education program for minority high school students.

Promotion of mathematics and science. The following are examples of agency and department programs and activities designed to increase or maintain interest in mathematics and science: (1) *Career Development Program* — seventh- and eighth-grade students in Arkansas participate in career orientation classes as part of their curriculum. One segment of the course program covers careers in transportation. Members of the Arkansas State Highway and Transportation Department participate in this program. Using a videotape and brochures, the Department representative emphasizes the importance of mathematics, science, and communication skills in the highway

and transportation profession. (2) *Mentor Program* — Though not specifically designed to actively recruit or encourage young people to pursue mathematics or science, The New York State Department of Transportation noted an active support of a New York State program "The Matilda Cuomo Mentoring Program." The Department encourages its employees to volunteer their time to be involved on a one-on-one basis with young people (students 10 to 14 years old). Since the program will have a role model influence on these young people, the effectiveness of encouraging mathematics and science or engineering will be a function of the professions of the volunteers. Examples of mentoring programs sponsored by state highway agencies and departments of transportation are the "Adopt-A-School" or "Adopt-A-High-School" programs reported by Oklahoma, Texas, and Virginia. These programs encourage the employees to volunteer their services for mentoring, speaking, guidance, and judging at science fair activities. (3) *Mathematics Competitions and Science Fairs* — Alaska reported the sponsorship of an annual mathematics competition at the junior high school level. California reported participation in both mathematics competitions and science fairs at the high school level.

American Association of State Highway and Transportation Officials

During 1988, the American Association of State Highway and Transportation Officials (AASHTO) surveyed its member departments to quantify and qualify recruitment problems and practices for selected transportation professionals, salary levels, and retention problems and practices (*20*).* Forty-two departments responded to the survey. Table 4 summarizes the results of the recruitment survey.

Approximately half of the respondents to this survey indicated no current problem of recruiting civil engineers. However, many indicated an expectation that a problem would surface during the next 5 years. The findings of the survey conducted for the current project closely resemble the findings of the 1988 AASHTO survey in that summer employment and college contacts were reported as the predominant practices.

During 1989, AASHTO convened a multidisciplinary task force on transportation professionals development and recruitment (*21*). The objective of this task force was to develop a course of action for member departments outlining steps the departments or AASHTO may implement to improve the overall supply and quality of transportation professionals.

One product of this task force was the publication in 1990 of "The AASHTO Guide to Recruitment and Retention of Civil Engineers" (*21*). The purpose of this guide is to assist state highway agencies and DOT's in the evaluation of existing recruitment efforts and to plan and implement future efforts.

AASHTO has also moved forward with the planning of the Transportation and Civil Engineering (TRAC) Careers Centers Concept under the direction of the Task Force on Civil Engineer and Transportation Professional Development and Recruitment (*19*). Envisioned to be coordinated through a central office and regional career centers, the TRAC program has the following three objectives: (1) creating programs to expand the size and quality of the civil engineering pool; (2) focusing of these programs to promote engineering careers in transportation; and (3) addressing the long-term needs, supply, and quality of transportation professionals in all transportation-related fields.

Initially, the TRAC initiative foresees the following three programs: (1) *National Outreach Program* — Targeted toward high school and junior high school students, the program will coordinate visits to the schools to discuss and promote careers in civil engineering and transportation. The program envisions these visits being conducted via colleges and universities through the regional University Transportation Centers, individual civil engineering and transportation programs, and civil engineering and transportation student organizations; professional and industry organizations; and individual state highway agencies and DOT's. (2) *National Summer Jobs Exchange Program* — Targeted toward college students who wish to have summer employment in another geographic region. (3) *National Electronic Bulletin Board System* — Targeted toward junior high school, high school, and college students interested in obtaining information on civil engineering and transportation career descriptions and opportunities.

The TRAC program is still in the developmental phase.

Table 4. Summary of AASHTO survey regarding the recruitment efforts of state highway agencies and departments of transportation. (Source: Ref. 20)

Recruitment Practice	Agencies Using the Practice	Agencies Not Using the Practice
Summer Employment	32	11
High School Contacts	13	30
College Contacts	30	13
On-Campus Departmental Activity	11	31
Student-Mentor Program	5	36
Pre-Career Development Program	13	27
Post-Employment Development Program	29	13

Federal Highway Administration

The Federal Highway Administration (FHWA) is committed to improving the recruitment and retention of university graduates into the transportation field, particularly in government service, and with special emphasis on underrepresented groups. FHWA has just initiated an internship program targeting women and minority students, called Summer Transportation Intern Program for Diverse Groups (*22*). College juniors, seniors, and graduate students who are majoring in civil or transportation engineering are eligible. The program will place students in summer jobs with FHWA or with the Urban Mass Transportation Administration. The students will receive a stipend of $3,500 plus travel expenses. For the summer of 1991, 10 internships were made available, and the intent is to expand this to as many as 50 internships in future years. Announcements of this program were sent to all Historically Black Colleges and Universities (HBCU), other institutions with traditionally large numbers of minority graduates, and all universities known to have transportation programs.

A second FHWA program that has achieved notable success in attracting participation by minorities and women is the Grants for Research Fellowships Program operated by the National

*References cited in Part 2 are included in Part 1, beginning on p. 20.

Highway Institute (*23*). This program offers fellowships of 3 to 12 months' duration for undergraduate and graduate students to work on selected research projects of interest to FHWA. Most of the research fellows work on-site at an appropriate FHWA laboratory. The program announcement is widely distributed each year, with special emphasis on reaching minority and women applicants. The number of minorities and women who apply depends somewhat on the nature of the projects included in the announcement. Higher numbers apply in years when there are more projects in the areas of mathematics, statistics, computer science, planning, and similar areas, as opposed to such areas as structures, materials, and hydraulics, where there are usually fewer applicants from underrepresented groups. On average, about 45 percent of the applicants and selectees have been women, and 20 to 25 percent have been minorities. Approximately 200 students have participated in the program over the past 6 years. Of these, 10 have been selected for permanent positions with FHWA, including 2 minority students and 1 woman. A current goal of the program is to increase minority participation and the effectiveness of the program in attracting women and minorities into permanent positions.

EFFORTS OF DEPARTMENTS OF CIVIL ENGINEERING/TECHNOLOGY

A questionnaire survey was sent to 224 civil engineering departments and 114 civil engineering technology departments in the United States to identify efforts to increase the pool of civil engineering students. Eighty-three of the civil engineering departments and 30 of the civil engineering technology departments responded to the request. Subsequent follow-up included a second mailing to 100 colleges and universities. A summary of the practices of civil engineering departments and civil engineering technology departments to increase and maintain interest in civil engineering or mathematics and science is presented in Appendix B.

Programs and Activities Practiced

The responses reveal that few civil engineering departments and civil engineering technology departments are active in recruiting and retaining students in civil engineering. The nature of the responses indicates that these efforts are generally undertaken by the college of engineering or via the entire educational institution, especially with respect to minority and women recruiting, and most efforts are directed toward engineering in general, rather than to any one specific discipline (i.e., civil engineering).

The responses of those civil engineering and civil engineering technology departments that are active indicate that these efforts are typically divided into the following categories: pre-college career information and support programs, and undergraduate information and support programs.

The pre-college career information and support programs are directed toward individuals in high school. Some programs were specific to minorities and women. The activities within this category, currently in use by the responding departments, include pre-college programs, videotapes and printed materials, open houses, high school visits, contests and science fairs, and summer programs and workshops.

The undergraduate information and support programs are designed to assist those undergraduates who have not "declared" a major, who are interested in changing their declared major, or who have declared civil engineering as their selected career path. For these individuals, the program's mission is to maintain or enhance their interest in civil engineering. The activities of the civil engineering and technology departments include ASCE student chapters, ITE student chapters, videotapes and printed materials, career days and open houses, cooperative education, and scholarships and student aid.

Promotion of Civil Engineering

Although few civil engineering departments are reportedly active in recruitment activities, the following specific efforts were identified: (1) development of information pamphlets and recruiting posters to assist in recruiting high school students (a follow-up information letter is sent to the potential student); (2) mailing of information specifically regarding civil engineering to applicants who perform well on the standard ACT or SAT exams; (3) mailing of correspondence, especially to those future students who have already indicated civil engineering as a preferred field of study; (4) identification of potential engineering students via the Educational Testing Service Search followed by forwarding of civil engineering career information (one department forwards ASCE's brochure, "Is Civil Engineering for You?"); (5) encouragement of faculty and students to visit with high school groups, especially science and mathematics classes (this activity is often performed through the ASCE student chapter); (6) several of the departments noted specific attempts to attract freshman engineering students who have not declared a particular engineering major (these efforts include: inviting freshman engineering students, usually in conjunction with Parents' Day, to a reception and tour of the civil engineering department; inviting freshman engineering students to an ASCE student chapter meeting; providing a faculty member of the civil engineering department to speak to the freshman engineering orientation class on career opportunities in civil engineering; and encouraging the publication of civil engineering related topics in the college of engineering student magazine).

In addition to the foregoing activities, a descriptive example of one civil engineering department's efforts to increase interest in civil engineering is presented below.

The Civil and Environmental Engineering (CEE) Department at Utah State University initiated a workshop program, "Engineering State," to help remedy the declining number of CEE graduates (*24*). Its purpose was to expose incoming college freshmen to the areas of study within civil engineering, thereby increasing the likelihood that more students would select civil engineering as a career. The program, which was first implemented in June 1990, included the following: (1) *A Pre-Workshop Challenge* — prior to attending "Engineering State," the students met with civil engineers who live in their home communities; then, at the workshop, they reported on their community engineering project. (2) *A Scholarship Exam* — each student participated in a 2-hour exercise involving mathematics and reasoning skills, and scholarships were offered to those with the highest scores. (3) *A Research Challenge* — participants were given 2 hours in the library to research and write about an engineering subject; this exposed students to the research, writing, and cognitive demands of engineers.

"Hands-on" exercises were also included to give the students an insight into structural, geotechnical, fluid mechanics and hydraulics, environmental, transportation, and water resource engineering.

One hundred and sixty-one students participated in the program. On completion of the program, they received small scholarships; departmental awards were also given for outstanding performance in the challenge sessions.

While the cited efforts increase the awareness of civil engineering, several departments stated that success has been limited. The Civil Engineering Department at The Johns Hopkins University, for example, concluded that salaries competitive with other fields of engineering would do more to enhance the attractiveness of civil engineering than any other single factor. They also suggest creating an aura of excitement about new challenges in the civil engineering field.

Promotion of Engineering

Very little information has been found regarding the involvement of civil engineering departments in promoting engineering in general. Some departments participate, as part of the college of engineering, in summer pre-college programs to increase interest in engineering. These programs target junior high and high school students and, specifically, underrepresented groups.

Promotion of Mathematics and Science

The civil engineering departments reported very few incidents of focusing on increasing interest in mathematics and science. Other than participating with the college of engineering in pre-college programs and efforts that emphasize the importance of mathematics and science to junior and senior high school students, very few activities were mentioned except as indicated in the following paragraphs.

The Civil Engineering Department at Wayne State University noted a summer project that permitted a high school student and her mathematics teacher to participate in one of the department's NASA-funded research projects. At the end of the summer, the mathematics teacher indicated a willingness to educate his students on what he had learned about the civil engineering profession.

Several civil engineering departments pointed out that talking to high school groups and mathematics and science classes during high school visits made by an ASCE chapter, and explaining the importance of mathematics and science, is another method of promoting mathematics and science interest.

Some civil engineering departments involved in "mentor" programs or "adopt a high school" programs use that opportunity to promote mathematics and science as well as civil engineering to their protégés.

INSTITUTIONS OF HIGHER EDUCATION

Programs and Activities Practiced

Educational institutions are practicing several different approaches to motivate and prepare students for higher education and professions in engineering and other mathematics- and science-related professions. Through these approaches, the institutions are seeking to achieve the following objectives: enlarge students' knowledge base and extend their scientific awareness; encourage students to begin planning early in their education for college and a career in engineering or technology; provide in-service training for teachers; promote collaborative educational research endeavors; and promote challenging academic opportunities for talented college-bound students.

While many of the approaches are designed to target the general student population, a large number are specifically designed to target underrepresented students (minority groups and women). They specifically address the problems encountered by minorities and women that lead them to become underrepresented in the fields of mathematics, science, and engineering. These problems include poor self-image and self-confidence, lack of role models, inadequate counseling, and curricula that emphasize theory over practice (*25*).

Taking the participants' educational status into consideration, the approaches practiced may be classified into two categories. The first category, "pre-college programs," includes activities designed to target grade school students; the second category, "undergraduate programs," includes activities designed to target students already enrolled in college.

The activities practiced by the *pre-college programs* may be categorized as intervention, summer employment, career guidance, mentor and protégé programs, teacher training programs, family programs, cooperative education, university and college open houses, and miscellaneous activities (career information material, open houses, scholarships).

The activities practiced by the *undergraduate programs* may be similarly categorized as mentor and protégé programs, cooperative education, television and public radio programs, freshman orientation programs, tutorial services, and miscellaneous activities (career information materials, open houses, career days, scholarships).

A summary description of some of the foregoing strategies follows. Example programs adopted by the educational institutions to increase and maintain interest in engineering, mathematics, and science are described in more detail in Appendix C.

Intervention Programs (Pre-college). These programs can sponsor an array of student activities that fall into one of five categories. Although the mix may vary, these five areas set the intervention model apart from other educational efforts (*25*). The five categories are as follows:

1. *Academic Program Enrichment*—The various forms of enrichment activities include: (a) summer pre-college programs (these are typically 1-week to 8-week summer programs in which students meet and learn study skills, work on science projects, listen to speakers in the field of engineering, science, or mathematics, and go on field trips and tours); (b) academic school year pre-college programs (these programs, offered to selected students during the academic school year either during school hours or after school, feature activities that vary and may include tutoring, test preparation, academic counseling, field trips and tours, guest speakers, and hands-on experience); (c) Saturday morning enrichment programs (these programs provide enrichment courses in mathematics and science for students in grades 6 through 12); (d) student outreach programs (these are engineering and science outreach programs designed to enrich the science experience of elementary and junior high school students

and encourage them to aspire to careers in scientific and technological fields).

2. *Instructional Applications*—Mathematics and science course content can be linked to real-world applications in many ways, from providing teachers with special training and materials, to having working engineers review texts and supply applications-related supplementary material.

3. *Student Internships and Research Projects*—Through the guidance of certain intervention programs, students may seek college-level research projects or internships. These activities are enormously motivating and beneficial to students. Often these experiences help convince them to go to college.

4. *Academic Advising and Counseling.*

5. *Science Fairs, College Fairs, Industry and College Visitations, and Field Trips.*

Summer Employment Programs (Pre-college). These are typically industry-funded programs. They are especially important because they not only provide financial support to participating students, but also expose the students to workplace expectations. Summer jobs present opportunities to see professionals at work and highlight the importance of communications, teamwork, and work ethics. The programs usually identify capable students interested in engineering studies, place them in a work environment related to an engineering field, and challenge them with an academic program that leads to completion of an engineering degree.

Career Guidance Programs (Pre-college). These programs are designed to create career awareness among students in the early grades and offer continuing engineering and science-related experiences during the remaining school years.

Mentor and Protégé Programs (Pre-college and Undergraduate). These are programs that could be described as long-term, personalized intervention programs. They provide long-term support and encouragement that young students need to stay interested in science and mathematics and eventual careers in science and engineering. This is done by linking the students with successful role models who are willing to share positive and negative experiences with them. Also, this type of program will make parents more aware of opportunities for their children and, hence, have a positive effect on other siblings in the family and on friends at school; also, it will make teachers more sensitive to actively encouraging students to take science and mathematics classes.

Teacher Training Programs (Pre-college). In-service training for elementary, middle, and high school teachers and counselors is provided through these programs. Workshops focusing on hands-on, investigative science activities selected to enhance classroom instruction, motivate students, and provide a stimulating learning environment are an aspect of these programs. The activities focus on process skills, higher order cognitive skills, mathematics problem-solving skills, and language art development. These workshops will help teachers encourage their students to pursue technical careers.

Family Programs (Pre-college). This type of program permits parents and young children to learn together and simultaneously involves parents in their children's schools.

Cooperative Education Programs (Pre-college and Undergraduate). These programs include: (1) School–college partnerships—In this type of program, talented students, usually high school seniors, are given the opportunity to enroll in regular university freshman-level courses as part of their senior year academic program. These courses are sometimes taught in the high schools by high school teachers whose academic credentials and teaching experience qualify them for an adjunct instructorship at the university; university credits earned through this type of program are recognized at several colleges and universities nationwide for degree credit, exemption from similar courses, and advanced placement. (2) Work-study programs—These programs are designed to bring the worlds of education and engineering practice together through alternating sessions of full-time work and full-time study. On the job, students learn first-hand about their potential career by working directly with professionals in their field; in the classroom, students study the theory that makes their work meaningful. This helps students integrate theory and practice, confirm career choices, investigate potential job opportunities, and become better graduates. (3) Pre-teaching co-op programs. These are programs that introduce undergraduate engineering students to the rewards and responsibilities of teaching engineering through cooperative education positions as faculty assistants (interns) in appropriate introductory engineering courses. Through the program, students are motivated to consider and pursue a graduate degree and an academic career.

Television and Public Radio Programs (Undergraduate). These include television series that are aired on both public and commercial TV. Curriculum materials are made available to teachers interested in using the series in their classrooms. The series do an excellent job in raising student awareness of science and technology, and serve to spark curiosity. Public radio programs can similarly attract students into technology and engineering by giving the audience a glimpse of technology and engineering activities.

Freshman Orientation Programs (Undergraduate). These programs are offered by some educational institutions to reduce student attrition. They are designed to help freshman students make the transition from high school to the university environment. The program activities help students to feel more secure and competent during this period of adjustment.

Tutorial Services (Undergraduate). Some colleges of engineering have instituted counselor-tutorial programs within their respective departments. Programs are optional special help classes offered to beginning students to assist them in their technically demanding courses of mathematics, physics, and chemistry.

Promotion of Civil Engineering

Among the recruitment efforts of admissions offices at the educational institutions is the dissemination of large quantities of engineering career literature, admissions information, and financial aid applications, as well as information concerning opportunities offered by the institution and its college of engineering.

Other than the information already presented here (and with the exception of the efforts of a few educational institutions), little is being done through the institutions to promote civil engineering. By and large, civil engineering departments are expected to accomplish this mission.

Among the academic institutions that are in fact active in promoting civil engineering (outside the civil engineering depart-

ment) is the New Jersey Institute of Technology (NJIT) through its Center for Pre-College Programs (*26*). Recognizing the importance of a proper sequence of mathematics and science courses for potential engineering students, a special pre-college program was created at NJIT. This program recognizes that many minorities and women are unfamiliar with the role of civil engineering in urban life, and generally would not even consider careers in this area. This problem, often combined with undeveloped curricula and inadequate and negative counseling, severely limits the opportunities for these students in civil engineering.

The NJIT program, entitled "Introduction to Urban Engineering," is a summer pre-college program for junior high students (*26*). It has a primary focus on civil engineering and covers such topics as urban planning, transportation engineering, energy systems, and environmental science, including instruction in computer programming and communications. A follow-up program in urban engineering is designed for high school students.

Promotion of Engineering

Colleges of engineering are currently undertaking a variety of efforts to promote engineering and attract students to the field of engineering. These efforts and activities were discussed earlier. In addition to these efforts, specific recruitment and retention efforts are practiced in certain institutions. Of these, five will be discussed in this section.

Transfer Programs and Master Technician Programs are two examples of recruitment efforts. The Minority Engineering Program is a retention activity designed to assist students majoring in the field of engineering to remain in college and graduate as engineers. The Women in Engineering Program aims at increasing the representation of women in engineering. The Speed School Freshman Orientation Program is also a retention activity.

Transfer Programs. Transfer programs are designed to assist students — who may come from other programs within the university, liberal arts colleges, or 2-year colleges — to complete the transition into the engineering curriculum.

Engineering schools have two basic types of articulation programs with liberal arts colleges. In what is generally referred to as a 2+2 program, students spend their first 2 years fulfilling general education requirements; they then complete 2 years in an engineering and engineering technology school or college.

In a second type of transfer program, referred to as 3+2, students attend a liberal arts college for 3 years and engineering school or college for 2 years. Upon completing the engineering program, the students receive bachelor's degrees from both schools.

In both 2+2 and 3+2 programs, statistics show that transfer students perform as well academically as students who begin their studies at the engineering school (*27*).

Engineering and engineering technology schools also accept transfer students from 2-year college programs into their 4-year programs. Such transfer programs operate in accordance with articulation agreements established between the participating institutions. Students are made aware of the courses they should take at the 2-year school to fulfill prerequisite requirements of the engineering or technology program into which they plan to transfer.

Master Technician Programs (*28*). There exists a broad spectrum of opportunities available to students desiring a career in the engineering area. The engineering team comprises the engineer, engineering technologist, engineering technician, and craftsperson. Various combinations of individuals from these groups may constitute a team for the successful completion of a given engineering task, project, or program. While the education levels of the various members typically differ, the total cohesive combination of their talents is what makes the overall project a success.

Although many students express interest in becoming engineers, a number of factors may contribute to the nonfulfillment of this desire. Understanding the engineering team concept introduces to these students other options they can pursue that will allow them to be involved in and contribute to the overall engineering effort.

Educational institutions are developing programs to attract these students and present them with the chance to decide for themselves either to remain at their current educational level, if it satisfies their personal need, or to continue with their education and advance to a higher education level. This is an appropriate context for efforts to expand the overall engineering pool.

The 2+2 Master Technician Program is one example of this type of program. The center for this program is the Thomas Nelson Community College, Hampton, Virginia. The concept of the program is to determine which students in grades 9 and 10 would be interested in pursuing a career as an engineering technician. Once identified, these students enter the program in grade 11. In addition to their normal studies, they take courses in mathematics, physics, electronics, chemistry, and laboratory science in preparation for the next phase of their education. Upon graduating from high school, they enter the Community College fully prepared to successfully complete the 2-year program in Electronics/Electromechanical Engineering Technology.

Once in the field, former students can remain as technicians or continue with their education and advance up the engineering team ladder.

The Minority Engineering Program (*11*). The Minority Engineering Program (MEP) incorporates components designed to accomplish three primary objectives: (1) Build MEP students into a supportive academic community achieved through formal orientation courses for new freshmen, clustering, and student study center. (2) Deliver appropriate academic support that could include, along with the traditional tutorial services, effective use of pre-freshmen mathematics and science courses, supplementing of early mathematics and science instruction, and close monitoring of student progress. (3) Facilitate the personal and professional growth of MEP students. This could be achieved by role model speakers and field trips to industry; minority student organizations; and preprofessional employment, including summer jobs, part-time jobs, co-ops, and internships.

The MEP has administrated motivational, recruitment, and retention programs for pre-college and college-level minority students. These programs have aided in the identification and motivation of a larger pool of students who express interest in engineering and other mathematics-based fields as possible career choices.

Prospective students who demonstrate high potential and indicate mathematics and science and engineering as career interests are seriously recruited by MEP staff and students. They are

continuously provided with information regarding an engineering career as well as support services available to them on the universities' campuses.

The increase of minority enrollment at an institution may in some cases be related to the nature of its MEP activities. An example of this is the California Minority Engineering Program, where the idea of MEP was originated at California State University, Northridge, in 1973. In 1982, the Mathematics, Engineering, Science Achievement (MESA) organization at the University of California, Berkeley, undertook to establish MEP's at other California engineering schools (*29*). By 1987–1988, MEP's were operating at 16 of the 19 engineering schools in public universities in the State, serving more than 2,600 African-American and Hispanic-American students. Surveys indicate impressive retention success among MEP participants, who were retained at a substantially higher rate than that of all engineering students.

Women in Engineering Program (*27,30*). This program offers a comprehensive approach aimed at increasing the representation of women in the field of engineering. Activities focus on recruitment, retention, and relations with industry and alumni. Each of these factors is critical to the overall success of the program and all are strategically interwoven. Many universities have undertaken the establishment of a women-in-engineering program. The following is one example at Purdue University.

Purdue University initiated the Women in Engineering Program in 1968. The combination of recruiting and retention activities has resulted in Purdue graduating more women engineers than any other institution.

The recruiting activities of the Purdue program include: career education film; pre-college summer program for high school students; grade school and junior high poster; prospective student identification (the Educational Testing Service Student Search is used to identify potential engineering students, and these students are then sent career information concerning engineering and invitations to on-campus programs); and Women in Engineering Career Day.

The program's retention activities include: merit awards—scholarships based on academic achievement that are awarded to both beginning freshman students and continuing students (awards ranging from one-time awards of $500 to continuing awards of $2,000 a year are sponsored by grants from industry); seminar—Women in Engineering (ENGR 194), a 1-credit course that is designed to give beginning women students an overview of the emerging role of women in engineering (the class makes extensive use of role models and 1-session workshops to accomplish the goal); seminar—Women in Transition (ENGR 195W), a 1-credit course that is designed to provide senior women students with experiences that will help them make a successful transition from student to working engineer; *Semester SWEep*—a newsletter designed by the student section of the Society of Women Engineers (*Semester SWEep,* published twice a year, provides the women engineering students, alumnae, prospective students, and industry with information about women in engineering at Purdue); and Society of Women Engineers—Purdue has the largest enrollment of women engineering students in the United States and more than one-half are SWE members. The Purdue chapter is very active and has demonstrated considerable success in its professional and social activities. Much of the success of the Women in Engineering Program can be attributed to a dedicated SWE student chapter and the services it provides.

During the 1989-1990 school year, more than 8,000 young women were touched by one or more of the programs of the Women in Engineering effort at Purdue.

The Speed School Freshman Orientation Program (*31*). Nationwide research efforts into student retention initiatives suggest than an extended orientation experience is needed to provide students with critical connectors during the first few weeks of their collegiate career. Inspired by this, the Speed Scientific School, one of 11 degree-granting academic units within the University of Louisville, Kentucky, began a campus-wide effort in 1988 to reduce student attrition by offering a freshman orientation course. This major-specific, accredited orientation course is conducted during the first few weeks of the fall semester to help students feel more secure and competent during the transition period from high school to the university environment.

The course objectives include active use of various on-campus academic and nonacademic resources, personnel, and facilities; development of student peer network relationships and use of faculty mentoring; improvement in academic and study skills; commitment to the value of higher education; and explanation of the relationship between academic preparation and chosen career.

A wide variety of teaching strategies and learning activities is employed to accomplish the above objectives. The course content was specifically tailored to cover areas pertinent to engineering students. Ten modules of instruction were developed to be presented in the 10 class meetings. The course uses "Academic Gamesmanship: Becoming a Master Engineering Student," published by the National Action Council for Minorities in Engineering, Inc. (NACME), as the course text. This publication is a clear and concise guide that provides an overview of the issues and concerns facing engineering students.

One course section was offered in 1988, and three in 1989, with a limit of 25 students in each section. A diverse student population was selected for each course. Initial student evaluations have been very positive. The students perceive substantial benefits resulting from their participation.

Promotion of Mathematics and Science

Recognizing the importance of enlarging the students' knowledge base and extending their scientific awareness in mathematics and science is essential to expanding the engineering pool, and likewise the civil engineering pool. It was found that academic institutions at large are very active in their student outreach efforts to promote mathematics and science.

Their activities may be summarized as intervention programs, teacher training programs, collaborative work with mathematics and science teachers to improve curriculum, and school visitation in which emphasis is placed on the importance of mathematics and science to the world of engineering.

A pilot program established three decades ago provides an example of what academic institutions are adopting to increase student interest in mathematics and science. This program is the "Mathematics, Engineering, Science Achievement Program" (*29*). Its primary objective is to increase the number of underrepresented minority students who graduate from a 4-year college or university with a degree in a mathematics- or science-related field.

MESA selects students with an aptitude and interest in mathematics and provides them with academic and enrichment activities, such as study groups, field trips to industry, scholarship incentive awards, summer enrichment programs, freshman orientation, academic and career counseling, summer employment, and professional development training.

EFFORTS OF PROFESSIONAL ORGANIZATIONS TO INCREASE INTEREST IN CIVIL ENGINEERING

American Society of Civil Engineers

Career Guidance Activities

The American Society of Civil Engineers (*32*) is involved in numerous activities relating to civil engineering career guidance. The purpose of these activities is to motivate highly qualified students to consider a civil engineering career path, to encourage life-long development of civil engineers, and to encourage ethnic and gender balance in the civil engineering profession.

High school students and first- or second-year college students have been the traditional target group for these career guidance efforts. Recently, efforts have also been directed to younger age groups (elementary and junior high students).

The career guidance activities range from encouraging strong elementary school programs in mathematics and science, to encouraging engineers of all ages to continue their education. A summary of the activities of the different society elements is described below:

- **Education Activities Committee (EdAC)**

1. The *Committee on Career Guidance* (CCG) (*33*) was established in 1987 in response to ASCE's task force study on the shortage of civil engineers. During that period, CCG was continually developing new guidance material. Its activities include provision of a handbook, *ASCE's Handbook for Career Guidance,* for use by sections and branches in performing local outreach; development of a guidance display for use at conventions and meetings; provision of awards for the International Science and Engineering Fair; maintenance of a relationship with the Junior Engineering Technical Society (JETS), which coordinates career guidance work for all the engineering societies; and, with respect to ASCE's series of guidance materials entitled "Is Civil Engineering for You?", CCG has updated and redone the video and slide show elements of the series. It also oversees the publication of the brochure and flyers. This guidance series helps engineers give effective guidance presentations to potential recruits into the profession.

The materials are targeted primarily toward high school students, but are also useful for junior high school and incoming college students. Four different formats are available: (a) *sixteen-minute narrated slide show*—describes the various subdisciplines within civil engineering and shows examples of representative projects; (b) *fourteen-minute videotape*—a videotape version of the slide show described above; (c) *fourteen-page brochure*—describes the work done by civil engineers and answers several questions that an interested high school student might ask about the profession; and (d) *four-section flyer*—an abbreviated version of the brochure described above.

With the same objective of producing an adequate number of highly qualified entrants into the civil engineering undergraduate degree program, the marketing group "Naidus Group" recently developed a marketing plan for career guidance. The plan, which is discussed in detail in a later section, includes specific strategies for attracting young people to civil engineering, with special emphasis on women and minority students.

2. *Committee on Student Services* (CSS) (*32*) distributes the "Is Civil Engineering for You?" brochures to student chapters and clubs and encourages them to engage in guidance activities. This is, however, a minor activity for the student chapters and clubs—less than 10 percent are engaged in career guidance for pre-college students. The main objective of the chapters and clubs is focused on retention of students in civil engineering.

According to the 1989 *ASCE Official Register,* the objective of student chapter programs is to "help students prepare themselves for entry into the civil engineering profession and society," while the student clubs "are intended to stimulate student interest in civil engineering and to provide society services to undergraduate students" (*33*).

3. EdAC furnishes the civil engineering departments with guidance material to help them with their pre-college programs.

- **Professional Activities Committee (PAC)**

1. The *Committee on Minority Programs* (COMP) has been active in career guidance efforts aimed to target students from kindergarten through 12th grade. For kindergarten through 6th grade students, COMP has developed a coloring book "Would You Like to be an Engineer?" It describes a civil engineer's role and accomplishments in an urban setting. The book was developed 5 years ago, and some 40,000 to 50,000 copies have been distributed. With respect to junior high students, COMP has prepared a 10-minute videotape, "Dream Your Own Dream," using an amusement park setting to present an overview of civil engineering and its different disciplines. The video emphasizes the involvement of women and minorities and describes the need to take mathematics and science classes in high school. And for high school students, COMP sponsors approximately 10 summer institutes for minority high school students each year. These are 2- to 6-week programs in each location, which reaches a total of approximately 200 students. This year COMP sponsored 13 summer institutes.

Presently COMP is looking at expanding its guidance effort for elementary students. Also, COMP recently submitted a proposal to change its name from Committee on Minority Programs to Committee on Equal Opportunity Programs as a means of expanding its efforts to include larger target groups.

2. The *Committee on Sections and District Councils* (CS&DC) (*34*), comprised of many sections and branches, is actively involved in career guidance activities. They have outreach programs and contact members designated to relate to high school students and guidance counselors. "Engineering Expressions" is an example of a pilot career guidance outreach program developed by ASCE's Buffalo Section and the Girl Scouts, geared for students aged 9 to 13. Basically, the program consists of four workshops that serve to introduce the students to engineering principles.

Other activities of ASCE sections and branches include involvement of high school and college students in essay and scholarship competitions; participation in the COMP summer institute program by sponsoring or partially sponsoring attendees to a summer institute; and support of ASCE student chapters and clubs within their geographic area.

3. The *Committee on Public Involvement* (CPI) is involved in getting state government and media support for ASCE career guidance programs.

- **Technical Activities Committee (TAC).** Several elements of TAC have education committees. Within the Highway and Surveying Division Committees, there has recently been increased interest in guidance activities, specifically with respect to attracting students toward those particular civil engineering specialties.

- **Joint Task Committee on Career Guidance.** This is a temporary committee, formed for the purpose of investigating the current status of career guidance within ASCE.

- **Washington Office**

1. The *Committee on Public Communications* (COPC), during 1989, funded a "Pioneers of the Future" advertisement in the Junior Scholastic magazine. The committee has also printed posters for general public awareness about civil engineering. In 1988 it sponsored a special campaign, "Civil Engineering—It Makes the Difference," in conjunction with Lifetime Learning Systems.

2. In addition, the Washington office responds to letters from the public, some of which have a career guidance aspect.

Professional Workshops

During 1987–1988, ASCE conducted a workshop entitled "Civil Engineering in the 21st Century" (*35*). At this workshop, which over 100 leaders in the profession attended, the history, the current problems, and the future direction of civil engineering were reviewed, including the specialty area of transportation. One of the products of the workshop was a view, presented by Harold Michael of Purdue University, on "What the Civil Engineer of Tomorrow is Going to Look Like." In his view, Michael identified the civil engineer, including the transportation engineer, as (*36*): having much more of a world view, dealing more with quality-of-life issues, more a manager of resources than in the past, a communicator, and relinquishing to technicians much of what civil engineers do now.

A principal conclusion of the study was that a clearly focused plan of action, endorsed by the entire profession, is needed. The plan must reestablish the position of civil engineering among other disciplines and delineate the role of civil engineering as the primary link between construction-related technology and society.

The study recommended the following general guidelines for ASCE to follow in planning its new policy: (1) ASCE should play a leading role in enhancing the professional status of civil engineers. (2) ASCE should advocate the development and implementation of visionary actions appropriate to practice, education, and research. (3) ASCE policy and leadership should be more representative of all segments of the profession including practitioners, educators, younger members, employers, and employees. (4) Civil engineers, as representatives of ASCE, must in the future attempt to participate in policy groups within related professional organizations and governmental agencies. (5) A national policy leadership action group within ASCE must be developed to foster strong ties to professional, educational, and governmental agencies.

Education and Continuing Professional Development for the Civil Engineer

During April 1990, ASCE sponsored the "National Forum on Education and Continuing Professional Development for the Civil Engineer." The overall theme of the forum was "Setting the Agenda for the Nineties and Beyond." The forum included 18 broad subject areas or tracks. Several topics were discussed, and recommendations on how educators, practitioners, and ASCE can influence education for the next decade and into the 21st century were suggested. The general observations and conclusions resulting from the 18 tracks were summarized by the steering committee (*37*). The committee categorized the issues as undergraduate programs, graduate programs, students, faculty, university and college facilities, continuing professional development, and steering committee recommendations of areas for ASCE initiative.

A need for ASCE to become much more comprehensively involved in career guidance, not as a euphemism for recruiting high school students, but true life-long guidance, consistently arose from the discussions. The objectives and the benefits of a life-long guidance program were presented and discussed. A recommendation that ASCE develop such a coordinated program was emphasized. The program would target the following groups: kindergarten through 8th grade, 9th through 12th grades, undergraduate and graduate schools, graduation to professional registration, and after professional registration.

The objectives of targeting the first and second groups are to aid youngsters in becoming knowledgeable about civil engineers and their work, and to make them aware of the mathematics and science requirements for entry into a civil engineering program.

The benefits that those two groups will gain from such a guidance program are threefold: (1) an understanding of the significance of the civil engineer's work, which should attract a great number of highly capable students; (2) for youngsters with interest, knowing the appropriate high school courses in time to take them; and (3) the conveyance of an enhanced image of the civil engineer to all students, including those opting to consider a career in civil engineering.

The objectives of targeting undergraduate and graduate schools are to introduce the civil engineering student to the requirements of the profession, the importance of acquiring effective communication skills, and the advisability of graduate degrees for entrance and advancement in various disciplines. This will help facilitate the transition from student to practicing engineer for both the employee and the employer.

For the graduation-to-professional-registration group, a formal internship program is suggested. This program would help the recent graduate mature into a knowledgeable and capable professional. The United Kingdom model, which requires a 3-year internship before the individual becomes a "chartered engineer," was suggested as an example. The benefit from such a program is that it provides a more structured and thorough path to design competence and professional registration. Also, employers in such programs become more actively responsible for the development and mentoring of young civil engineers.

Finally, the objective of targeting the last group, after professional registration, is to produce more competent civil engineers by providing these individuals with resources (publications, continuing education programs) and reference to other sources of development for all stages of their professional life. They will

provide better services and enhance other members' self-images as well as the public image of civil engineers.

Of utmost importance throughout all of these "guidance" activities is the continuing need to attract and retain women and minorities within the profession!

Among the forum's 18 tracks was the "Transportation Track." A career guidance activity with the objective of improving the quality and increasing the quantity of transportation engineers was recommended (*41*). The guidance activity would target four groups: (1) pre-high school students, (2) high school students, (3) civil engineering students, and (4) other target groups.

The specific recommendations developed by the track participants for targeting each group are outlined below.

1. Pre-high school students — Increase direct contact with elementary and junior high school students. Use transportation engineering topics as vehicles to excite young people about the challenges and opportunities in engineering. Improve the quality of guidance material. Demonstrate the importance of mathematics and science preparedness. Interface with elementary and junior high school teachers. Work with local science and children's museums on projects that demonstrate the excitement of transportation engineering projects.
2. High school students — Work with teachers and guidance counselors to encourage students to think about careers in engineering. Develop ASCE student chapter outreach programs where college students can interact with high school students. Tutor high school students. Investigate the possibility of implementing educational reforms to relax the teaching certification requirements at the high school level. A study needs to be undertaken to develop methods to use retired engineers and engineers who would be willing to teach on a part-time basis in the high school. Provide software to high schools.
3. Students enrolled in civil engineering programs — Target undecided majors for recruitment. Involve industry in recruitment programs. Recruit from community colleges. Fund undergraduate research experiences. Investigate recruiting students from 3+2 programs (that is, programs initiated at a liberal arts college in which a student transfers into engineering after 3 years). Provide private support for summer employment, co-op programs, and student loans. Involve practitioners in classroom activities. Introduce transportation engineering topics in orientation courses.
4. Other target groups — Investigate new methods for course delivery. Target second-degree students. Continue to develop recruiting tools that focus on getting women and minorities into the transportation engineering profession.

A key recommendation from the Transportation Track was that ASCE should strongly support a basic course in transportation engineering in all bachelor of science programs (*38*).

Marketing Plan for Career Guidance

The Naidus Group prepared a marketing plan for career guidance for the ASCE (*39*). To develop this plan, the Naidus Group drew upon research already conducted by ASCE, meeting minutes of society committees, other related reports, and informational materials. Additionally, the Naidus Group conducted two focus sessions early in 1990 (*40*). The first was conducted in Las Vegas with college educators from throughout the nation. The second was conducted in the New York metropolitan area and included high school guidance counselors, advanced placement mathematics and science teachers, and faculty advisors to high school mathematics and science clubs.

Four key findings from the focus sessions included: (1) an existing perception among students and faculty that civil engineering ranks below other engineering specialties, (2) a serious lack of understanding about what civil engineering involves, (3) inadequate mathematics and science preparation among junior and senior high school students, and (4) the fact that college educators reported that a majority of incoming freshmen identified engineering as a chosen profession, and most identified a specific engineering specialization.

On the basis of the above findings, the following conclusions were drawn: (1) Efforts to attract qualified students into the profession must be focused in the short term on junior and senior high school students. (2) The decision influencers in high schools are a very effective and efficient resource to target. (3) Primary attention must be paid to providing accurate and timely information on the civil engineering profession. (4) Efforts must be focused on better preparing elementary and middle school students in mathematics and science. (5) The incorporation of civil engineering career options into curriculum support materials will increase the students' and teachers' awareness of civil engineering. (6) Participation of practicing civil engineers as role models in student recruitment will be very effective.

The marketing plan details the development and implementation of an effective ASCE educational career guidance campaign. The plan includes specific strategies for attracting youngsters to civil engineering, with special emphasis on women and minority students. Various tactics are suggested for reaching out to students directly and indirectly through key influences (e.g., high school faculty and guidance counselors), as well as ASCE sections and branches and civil engineering department heads and student chapters at the college level.

Specific strategies include the following:

1. Audience identification — the best-qualified students in high schools that traditionally contain the most qualified students, the best-qualified students in other high schools, college students in engineering schools who have not made a career choice, the best-qualified female students in both high school and college, the best-qualified minority students in both high school and college, and individual high school or college students who request career information directly from ASCE.
2. Creation of a permanent framework of contact and recruiting within the school organization, both in high school and college, and in cooperation with the ASCE sections and branches, as well as with university civil engineering department heads.
3. Promotion of the positive image of civil engineering.
4. Student appeals — challenges and rewards.
5. Accurate information.
6. Key marketing concept — "Specialness of civil engineering."
7. Key theme lines.
8. Phased implementation of strategies.

Joint Task Committee on Career Guidance

As mentioned earlier, this committee was formed for the purpose of investigating the current status of career guidance within ASCE, and coordinating the development of an overall career guidance policy (*32*).

During 1990, the committee identified four student groups that ASCE should target to ensure a sufficient supply of high-quality civil engineers. These groups include all students between kindergarten and 12th grade, the best students at the junior and senior high school level who may be candidates for careers in engineering, students between their junior year in high school and sophomore year of college, and upper-level college and post-BSCE students.

With the target groups identified, the committee developed a policy for ASCE to follow in its career guidance plan. The policy recommends that ASCE support: (1) a program to encourage mathematics and science studies targeted to all students, (2) a concentrated program to orient junior high and high school students toward engineering studies in general and civil engineering in particular, (3) a promotional program to encourage high school juniors and seniors and college freshmen and sophomores to pursue undergraduate degrees in civil engineering, and (4) programs to advocate graduate study and faculty careers.

A "draft" summary of the committee's suggested activities for ASCE implementation includes:

1. Developing programs at the branch and section levels that provide for and encourage engineers' (practitioners and educators) participation in promoting science and mathematics studies in general and civil engineering in particular at all student grade levels.
2. Promoting interest in civil engineering by individual ASCE member involvement in classroom presentations, lectures, demonstrations, and career day programs in middle and high schools.
3. Encouraging high school science and mathematics teachers to provide exposure to civil engineering by encouraging participation in science fairs and mathematics competitions and scheduling specialized classes relating to civil engineering applications.
4. Educating high school science and mathematics teachers and guidance counselors in the requirements and availability of civil engineering curricula and the rewards of civil engineering careers.
5. Providing tours of construction sites and civil engineering related facilities to demonstrate the far-reaching applications of civil engineering in the everyday world.
6. Continuing and expanding advertising at the national level to increase awareness of civil engineers' contributions to society's everyday needs.
7. Coordinating ASCE activities and efforts with those of AAES, NSF, and other scientific research organizations to promote and expand an awareness and interest in science and mathematics at all grade levels.
8. Participating in programs that encourage women and minorities to pursue a civil engineering career.
9. Encouraging persons with civil engineering baccalaureate degrees to pursue graduate study and consider faculty careers.

Institute of Transportation Engineers

The Institute of Transportation Engineers (ITE) is active in recruiting and retaining civil engineering students in traffic and transportation engineering. ITE's activities in this concern include:

1. The bestowal of one or more annual fellowships to encourage outstanding civil engineering students to pursue graduate studies in traffic and transportation engineering. The Burton W. Marsh Fellowship is one example (*41*).
2. Support of student chapters, because they offer a valuable, yet untapped resource for promoting careers in transportation and traffic engineering. Student chapters, through the ITE program, are encouraged to undertake career promotion activities. These activities include: participation in open houses, job fairs, and career days; speaking to high school groups, freshman engineering classes, and prospective students and their parents visiting campus; and hosting technical and career-oriented presentations and seminars to which students outside the transportation field are invited (*42*).

Two of the criteria for the annual Outstanding Student Chapter Award are: (a) promotion of transportation engineering among the general student body, and (b) public service activities, such as promoting transportation engineering in high schools (*42*).

3. In 1990, ITE published a report, "*Attracting Students to a Professional Career in Transportation Engineering.*" It is a study on the shortfall of engineering graduates, particularly high-quality graduates in transportation engineering, conducted by ITE Technical Council Committee 2-32 (*43*). The following problems were among the findings of the study: recognition of shrinkage in the labor pool, further decline in engineering enrollments, greater attraction of engineering students to non-construction disciplines, where there is a perception of job security and higher wages, lack of mentors and role models for women and minorities, failure to motivate students at an early age to pursue mathematics and science, lack of involvement by industry and government to support education and training, reduced image of public service, and reduced quality and number of role models in engineering schools.

The study recognized and indicated that the image, salaries, and professional and social status of civil engineers are the major discouraging aspects of the civil engineering profession. The committee recommended that ITE develop a comprehensive recruitment program directed to students who have the potential to become quality professionals. This program should consist of the following activities: Develop separate materials (written and audio-visual) that enhance the image of the transportation engineer, inform the public and school children about transportation engineering, and seek to recruit high school and college students to a career in transportation engineering. Encourage and promote adoption of policies that provide for effective competition for the best professionals, especially relative to salaries and work environment. Elicit commitment from a large number of ITE members who will agree to provide personal contact to enhance the distribution of these materials and who will recruit individual students to the profession.

In addition to the above activities, ITE has several informational materials that may be used for recruiting. These materials include a brochure, "A Career in Transportation Engineering"; and two videotapes, "A Career in Transportation Engineering" and "ITE Overview/The Transportation Engineer: Working Toward Making Transportation Safe and Efficient" (*43*).

EFFORTS OF PROFESSIONAL, STUDENT, GOVERNMENTAL, INDUSTRIAL, AND RESOURCE ORGANIZATIONS AND AGENCIES TO INCREASE INTEREST IN ENGINEERING AND MATHEMATICS AND SCIENCE

Professional Organizations

National Society of Professional Engineers

The need for a steady supply of quality students going into engineering, science, and technology has been similarly recognized by the National Society of Professional Engineers (NSPE). Environmental, energy, and infrastructure challenges, combined with an increasingly technological society, strengthen the demand for technically qualified men and women in the work force. To ensure the flow of quality students through the engineering pipeline, NSPE is involved in numerous activities promoting engineering and technical careers.

- **NSPE Education Foundation, Pre-College Career Guidance Committee** (*44*). The activities of this committee include the following:

1. "Engineering and You" is an engineering guidance brochure for junior and senior high school students. Instead of explaining engineering in terms of its many disciplines, the brochure explains the profession in a generic and conceptual sense. This has been one of the most popular and widely used engineering brochures available. Colleges of engineering provide it with their recruitment packages, high schools make it available through their career resource libraries, and engineers distribute it when making presentations in the classroom. During 1989, 250,000 copies were distributed through NSPE, Engineers' Week, and the Junior Engineering Technical Society (JETS).
2. "Bicycle Video," still in its planning stage, is a 7- to 10-minute videotape that relates mathematics, science, and engineering to bicycle design. Appropriate for 5th to 9th grade students, the videotape will be fast-paced, energetic, and identifiable to this age group. The videotape was planned to be available by the 1991 Engineers' Week.
3. Engineering Explorer Posts have been developed by NSPE and the Boy Scouts of America, for men and women ages 14 to 20. Explorer posts encourage character building, citizen training, and fitness through career and recreational programs and projects.
4. The "National Engineering Design Challenges" is a competition, now in its second year, that challenges 9th through 12th grade students to solve a nonroutine, societal problem using mathematics, engineering, and technology. It also includes a 1-day professional training component for teachers and administrators. The competition is funded by the National Science Foundation and sponsored by the Junior Engineering Technical Society, National Talent Network (NTN), and NSPE (*45*).
5. NSPE, in cooperation with the U.S. Patent and Trademark Office, is involved in Project XL, which concerns programs that promote creative thinking and problem solving in primary and secondary schools. The major goals of Project XL are (*46*): (a) to generate awareness among educators, parents, businesses, government agencies, educational associations, and professional societies of the importance of applied thinking skills; (b) to motivate educators to use the inventive process as a vehicle through which students apply the skills of inquiry and critical thinking to real life problem-solving experiences; (c) to identify and, where possible, provide the tools needed to accomplish these educational goals; and (d) to establish a network of information, communication, and support for persons interested in participating in the Project XL vision.
6. "Guidance Volunteer Network" is presently implemented across the country to activate the above programs in the state and local chapters. These volunteers will serve as activators of pre-college programs for their chapters.
7. Two additional, future projects have been identified and are being planned: a teacher seminar for 5th- to 8th-grade teachers that would qualify for continuing education units (CEU's) for teacher certification (the seminar would inform the instructors of the various engineering disciplines, and explain how mathematics and science are applied to problem-solving); an instructional package available for the classroom (designed for grades 4 through 6, the package will provide hands-on activities plus resource information and materials on engineering).
8. The Education Foundation annually provides more than $1 million in grants and awards to students who are pursuing engineering degrees. The majority of the scholarships go to high school seniors. NSPE's chapter and state organizations play a large role in announcing the scholarships and sponsoring applicants. Other awards target college students and working engineers who want to obtain additional degrees.

- **National Engineers Week Committee.** This committee is responsible for the National Engineers Week, a long-established career guidance activity. During the 1990 Engineers Week, a new program "Discover E" was introduced. It is a student outreach program coordinated by the engineering professions. "Discover E" engineers visit pre-college classrooms throughout the week as part of a nationwide teach-in. Others sponsor extracurricular activities like contests, facilities tours, and engineer-for-a-day programs. Their aim is to inform students and teachers about the engineering profession. They also want to help students understand how mathematics, science, and engineering relate to the world around them. The committee has prepared a special packet and video for the engineers to use. More than 6,000 engineers and more than 750,000 pre-college students participated during the 1990 Engineers Week. The 1991 "Discover E" program will include a new activity for grades 4 through 6 adopted from the Society of Automotive Engineers' program, "A World in Motion" (*46*).
- NSPE, with the assistance of educational, business, and government agencies, sponsors "MathCounts," the first nationwide program to promote mathematics excellence for junior high students. It is a mathematics skills coaching program and a series of progressive competitions at local, state, and national levels. The program was developed as a positive and rewarding solution to reversing the current problem of mathematics illiteracy and as a way to make parents, educators, and the general public aware of career opportunities in mathematics.

The program builds skills, promotes strategic problem-solving, and drills students in dealing with complex problems. It provides an opportunity to bring 7th and 8th grades together and prompt lively exchange of mathematical ideas through competition.

MathCounts impacts the students at an age when they are formulating attitudes about mathematics and technology; when they can still elect to take college mathematics courses in high school to prepare them for future mathematics careers.

The competition phase of MathCounts begins in the schools. Students are coached in everything from basic arithmetic skills to linear algebra and polynomials. Between September and the national competition in the spring, students and teachers work together in quizzes and drills to develop teamwork and enhance mathematics skills. Successful students can advance to regional and state competitions which eventually lead to the national mathematics final.

During the 1989–1990 school year, 8,300 schools participated in the program (*47*).

- NSPE is working with the White House Office of Science and Technology policy to coordinate and link the guidance and education activities of federal agencies.
- **"Career Guidance in Engineering."** The Guidance Coordinator of NSPE, in cooperation with several students at Worcester Polytechnic Institute, performed a study in 1986 entitled Career Guidance in Engineering (*48,49*). The study included an extensive literature review about the career decision-making process of individual students. The possible factors found that might influence the decision-making were the environment, childhood experience, abilities and interests, self-concept, image of a vocation, personality of the student, and maturity.

The roles of counselors, teachers, parents, and industry were extensive, but tended to be idealized. Perhaps the most important finding was that *no single method of obtaining career information is completely effective by itself.*

The study also included a questionnaire survey sent to NSPE's liaison societies on their career guidance activities. Personal interviews with users of guidance materials followed. The study concluded that personal contact is the most effective single guidance medium; a combination of personal contact, written, and audiovisual material is ideal; and the guidance material should provide a clear definition of engineering, its subdivisions, and a clear and accurate description of the work engineers do.

The recommendation of the study was that a mix of personal contact with written and audiovisual materials would produce an effective guidance program. The study also stated that a mentor program is an effective alternative.

In addition to the literature review related to the career decision-making process, and the analysis of the questionnaires, the study reported on the *basic theories of career choice,* and the *various influential factors.* The major factors include the individual's concept of his or her abilities and desires, the image of a career field as visualized by the young person, and the satisfaction one perceives from a career field.

Other factors of importance are lifetime development opportunities, income potential, and the professional and social status of the career field.

Society of Automotive Engineers (SAE) International

SAE is a nonprofit educational and scientific organization dedicated to the advancement of mobility technology to better serve humanity and preserve and improve the quality of life. SAE is made up of a volunteer membership of 60,000 engineers and scientists. Through its 10,000 student members, SAE is represented at over 200 campuses in North America (*50*).

SAE asserts a unique capability to impact education in science and mathematics at the elementary and secondary levels, to induce high school students to enter engineering school, and to attract engineering students to careers in mobility engineering. Its uniqueness comes from the exciting attraction mobility products offer to young people.

Vision 2000. The Vision 2000 campaign enables SAE to reach all educational levels including elementary, junior high, high school, university, and graduate students through (*51*):

1. Development of specific educational programs such as supplemental teaching materials, for grades kindergarten through 12, to make mathematics and science fun and challenging and to show how they apply to technology in the world around us.
2. Development of free engineering software such as basic CAD programs for use by teachers and students on school personal computers.
3. Initiation and support of student and teacher awareness of the many facets of engineering in industry and management.
4. Expansion of successful existing SAE programs such as student design competitions into lower grade levels.
5. Development of specific programs for minority and female students to interest them in engineering education.
6. Development of a link between recent engineering graduates and their high school to show typical success stories.
7. Development of teacher awards for outstanding achievements and motivation through mini series, free teaching materials, and subsequent testing and feedback.
8. Organization of an academic and industry council to analyze specific U.S. needs and programs to solve identified problems.
9. Support of the NSPE MathCounts Program of seventh and eighth grade competitions in mathematics.
10. Service as a clearinghouse to place high school students and teachers as summer interns in industry.
11. Sponsorship of student design competitions.
12. Sponsorship of three students each summer as part of the Washington Internship for Students of Engineering (WISE).
13. The Graduate Student Forgivable Loan Program.
14. Teetor Educational Award Program.
15. Industrial Lecture Series.
16. SAE scholarships.

The keys to the success of Vision 2000 are (1) widespread member participation and (2) the maintenance of a communication network.

A World in Motion. A World in Motion, developed in 1990 by The Mazer Corporation for SAE International, is a multifaceted educational program designed to improve the science and mathematics education of 4th- to 6th-grade students and to encourage them to consider careers in mobility engineering (*51*). This program is part of Vision 2000, SAE's overall effort to help improve science education.

A World in Motion is a fully integrated print and videotape program that emphasizes a hands-on discovery of science principles through cooperative and interactive activities. Dedicated to arousing in children a sense of wonder and excitement about the world in which they live, A World in Motion will correlate with science textbooks at the 4th- to 6th-grade levels and enhance the existing curriculum.

The program will emphasize interactive learning, thus helping students understand abstract scientific and mathematical concepts by exploring the materials, discovering the concept, investigating the concept, and applying the concept.

SAE members are encouraged to play an active role in the program's implementation.

The program is made up of six phases or units. Unit 1 introduces students to a World in Motion by a videotape, "Super Motion in Nature." In units 2 through 5, students begin with learning cards, conducting experiments related to principles that apply to mobility engineering.

The program's benefits include its potential role as a base for initiating a forum between schools and local engineers. The resource box, displaying the program theme and SAE logo, will be visible in the classroom during the entire school year, giving SAE unlimited exposure. The program can be very easily updated by sending teachers new material and information. The design of the program encourages interaction of SAE members, teachers, and students.

American Society for Engineering Education (ASEE)

ASEE is a professional society of college and university engineering teachers, practicing engineers, industrial executives, and others interested in engineering education. The society seeks to advance education and research in engineering, science, and related fields. It conducts an annual College-Industry Education Conference; sponsors summer programs, workshops, and effective teaching institutes; conducts summer faculty research programs; cosponsors Frontiers in Education Conference; and carries out special research projects (*52*).

ASEE coordinates a summer program, "Washington Internships for Students of Engineering (WISE)," for third-year engineering students. The concept for WISE was proposed in 1978 in response to concern that few engineering students have the opportunity to learn about public policy, legislative and regulatory processes, and their relationship to technological change (*53,54*). The program consists of a 10-week summer academic program in Washington, D.C. Approximately 16 third-year engineering students are chosen each summer. They are outstanding scholars, representing a broad spectrum of engineering disciplines and universities. The average GPA of the participants is approximately 3.6. These students are selected and sponsored by one of the program's participating organizations, which include the American Institute of Chemical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, and the Society of Automotive Engineers. They are supervised by a faculty-member-in-residence, who is selected by a committee of the WISE Board of Directors prior to each summer after a nationwide search.

The four principal objectives of WISE are to: (1) increase understanding of policy among future engineering leaders, (2) sensitize engineers to engineering and public policy relationships, (3) enhance the image of the engineering profession, and (4) support policy activities of societies.

Through the WISE program, the student participant will interact closely with the leadership of the sponsoring societies. He or she will complete a paper that analyzes specific engineering and public policy issues on a topic of concern to the sponsoring society. These technical papers will be disseminated by the sponsoring societies and, if acceptable, published in an appropriate journal or magazine. The participant will also receive 5 quarter credits and a stipend of $2,400.

During the first 10 years, 152 students participated in the WISE program. WISE has had great success in attracting women students. The percentage of women participants rose from 11.8 percent in 1980 to 15.3 percent in 1988. There are two plausible explanations for the success WISE has had in attracting women students (*53*). First, public policy issues are a people-oriented aspect of engineering that may appeal more to female than male students. Second, much of the publicity material about WISE is disseminated through student sections of the sponsoring societies, and many of the societies select WISE students partly on the basis of the applicants' leadership role in student section activities. With a higher percentage of female than male engineering undergraduates involved in student society activities, women are more likely to hear about the WISE program in the first place and to impress selection committees with their extracurricular activities.

WISE has not had comparable success in appealing to minorities for the following reasons: (1) Financial difficulties may require minority students to seek summer employment that offers better compensation than the modest stipend awarded to WISE students. (2) WISE may be considered by minority students as a diversion from the mainstream engineering studies that will eventually lead to a promising career (*53,54*).

American Consulting Engineers Council (ACEC)

ACEC is a national professional association representing the business interests of independent consulting engineering firms. ACEC's more than 5,000 member firms annually design over $100 billion in constructed public works and private industry projects and offer a wide variety of engineering services (*55*).

In an effort to alleviate the predicted shortage of engineers, the Students Engaged in Engineering (SEE) program was founded in Washington, D.C., by the Consulting Engineers Council of Metropolitan Washington in 1988, and launched at the national level by ACEC. ACEC is encouraging its 51 member organizations to establish SEE outreach programs in every state.

The SEE program is an outreach effort to involve junior high school students in hands-on engineering instruction that will stimulate their interest in becoming engineers.

The program has been effective in awakening student interest in engineering through hands-on demonstrations, case histories, field trips, and other creative teaching techniques. Engineers participating in the program have experienced personal rewards from serving their community, working one-on-one with students, and improving the nation's future by interesting youth in engineering careers.

ACEC has various resources available to help promote the SEE program. Among them are the "SEEing is Believing" handbook, an easy-to-read pamphlet detailing how to start an SEE program; the SEE Idea Exchange Form; and the *SEE Newsletter.* ACEC will serve as a clearinghouse for activity ideas (*55*).

American Association of Engineering Societies (AAES)

Founded in 1979, AAES represents 25 U.S. engineering societies and nearly 1,000,000 engineers. Its objectives are to advance the science and practice of engineering in the public interest and to act as an advisory, communication, and information exchange agency for member activities (*56*).

The Engineering Manpower Commission, a division of AAES, annually surveys schools for enrollment and degree statistics in engineering and engineering technology (*57*).

Currently, AAES is involved in the establishment of the Engineering Society's Task Force on Pre-College Mathematics and Science Education. The 25 engineering societies represented by AAES have agreed to enlist more than 100,000 engineers as volunteers in this pre-college action. The goal of this pre-college action is to link each school in the country with an engineer who can provide assistance and supplementary materials to mathematics and science teachers (*57*).

The intention of AAES action is not to replace an individual society's pre-college programs, but to add to those activities and provide better coordination among them (*57*).

American Chemical Society (ACS)

ACS is a nonprofit scientific and educational association for professionals in the chemical sciences. Founded in 1876, the Society today has 137,000 national and international members.

A few of ACS's activities include the publication of numerous books, journals, and magazines; the provision of educational services for technicians, elementary and high school teachers; and a public information service that keeps the public and the media current on advances in chemistry (*58*).

The Society has identified the following generic faults that permeate the educational system: (1) the lack of national consensus in support of relevant science education at all levels; (2) the often inadequate preparation of, and lack of continuing education opportunities for, pre-college science teachers; (3) the inadequate environmental conditions under which chemistry is taught; (4) the low status of teaching as a profession; and (5) the underrepresentation of women and minorities in mathematics and science disciplines (*59*).

Specific policy recommendations to help alleviate the current crises have been stated by the Society (*59*). These include: pre-high school teacher education and assessment; secondary school faculty supply and development; and faculty development at the 2-year and 4-year college and university levels.

ACS supports quality chemistry education at many levels through a wide range of activities and services:

1. At local sections, ACS develops and implements local programs to serve special needs.
2. The Division of Chemical Education, among its other activities, develops, produces, and distributes standard examinations in both high school and college chemistry, and owns and publishes the *Journal of Chemical Education.*
3. The ACS Education Division manages programs directed toward young people learning physical science and chemistry for the first time, college students majoring in chemistry and related sciences, teachers of chemistry who instruct all age groups, practitioners of the discipline, and members of the general public who have an interest in the chemical sciences. Several of these programs and activities are (*60,61*): (a) *Project Seed*—provides economically disadvantaged high school students with the opportunity to participate in academic research projects in chemical laboratories under the direct supervision of faculty members. More than 2,000 students and 250 institutions have participated in this activity since 1968. (b) *Pre-High School Science*—promotes hands-on physical science in both classroom and nonclassroom settings; produces *Wonder Science* magazine for grades 4 through 6, and organizes and conducts science workshops for teachers. (c) *Chemistry Walks*—consists of a series of two-sided posters for display in the elementary school classroom. (d) *Chemists in the Classroom*—videotape designed to provide assistance to academic and industrial chemists who volunteer to work in elementary classrooms as teacher-resources. (e) *Working It Out*—videotape designed to promote science education to high school students, with emphasis on minority and women role models.

Student Organizations

Junior Engineering Technical Society (JETS) (62)

JETS, established in 1953, is a nationwide organization for pre-college students interested in engineering, technology, mathematics, and science.

JETS' goals are to raise the level of technological literacy; assist students to excel in their academic studies; demonstrate to students how technical knowledge is applied to solve real problems and contribute to the quality of life; inform students of career opportunities in engineering, technology, mathematics, and science; and provide contact with practicing engineers.

JETS program activities include the following:

1. Tests of Engineering Aptitude, Mathematics, and Science or TEAMS is an academic competition in which school teams of students challenge each other in biology, chemistry, computer fundamentals, English, mathematics, and physics. Often, TEAMS participation is used as a criterion by scholarship administrators and college admissions officers in assessing the meaningful extracurricular accomplishments of their applicants. In 1989, 12,000 students in 40 states participated in the tests.
2. The National Engineering Aptitude Search (NEAS), a guidance test, is available to help students evaluate their chances of success in engineering studies. The test focuses on higher-order thinking skills in the areas of mathematical understanding, scientific reading, and conceptual problem-solving. Since it was developed in 1975, NEAS has helped 175,000 students in grades 9 through 12 make up their minds about becoming engineers and technicians and helped parents, teachers, and counselors in advising them. Also, preliminary analysis indicates that the NEAS subscores and composite score are significantly correlated with graduation from engineering school, which is not the case with ACT or SAT scores.
3. *JETS Report,* a newsletter published during the school year, features valuable guidance information for college-bound students, high-tech news, JETS program news, and career information.
4. Minority efforts include the highly successful Minority Introduction to Engineering (MITE) program. JETS coordinated and was key to initiating the program in at least 50 sites nationwide.
5. Other activities include engineering design contests and guidance publications. In addition, JETS participates in sponsoring several national intervention programs, such as MathCounts and Discover E.

Governmental Organizations

National Governors' Association

In 1990, the National Governors' Association (NGA) completed the "Women and Minorities in Engineering Project" (*63*). The purpose of this project was to examine the pre-college and undergraduate intervention programs currently in existence and the efforts currently being made by the states to increase the participation of women and minorities in engineering. The report recommended that the governors support education reform aimed at improving kindergarten through 12th-grade mathematics and science education; provide programs that target women and underrepresented minorities to encourage science and engineering careers; work with the private sector to promote increased popular awareness of opportunities in mathematics and science and their importance to future U.S. competitiveness; encourage engineering colleges to implement programs for minorities and women; form a statewide cooperative effort to link organizations and individuals involved in increasing the numbers of women and minorities in science and engineering; and incorporate human resource development goals into state science and technology programs.

Presently, the NGA is planning to conduct an additional phase of this project. Its purpose will be to recommend more detailed and specific strategies to the governors for implementation.

National Science Foundation

The National Science Foundation (NSF) has numerous programs designed to enhance engineering education as well as the secondary school preparation of future scientists and engineers. Although it is not possible to cover all of them in this report, full details and points of contact are provided in the *NSF Guide to Programs* (*64*), which is available at most colleges and universities or directly from the Foundation. Summaries of two of the more pertinent programs follow.

Career Access Opportunities in Science and Technology for Women, Minorities, and the Disabled Program. In response to the underrepresentation of women, minorities, and the disabled in science and engineering, NSF has established the Career Access Opportunities in Science and Technology for Women, Minorities and the Disabled (ACCESS) Program. Two types of activities are supported under ACCESS: Comprehensive Regional Centers for Minorities, and Model Projects for Women, Minorities, and the Disabled. The regional centers are intended to develop a systemic approach to increasing the minority presence in science and engineering, through partnerships among colleges and universities, school systems, state and local governments, professional organizations, business, and industry. The objectives are to encourage and motivate minority students to consider technical careers; improve pre-college and undergraduate science, mathematics, and engineering education for minority students; and facilitate the transition of minority students from high school to college, the transfer of minority students between institutions, and the retention of minority students in undergraduate programs in mathematics, science, and engineering.

Individual projects conducted by the centers will focus on instructional and motivational activities. Specific mechanisms may include teacher workshops, faculty seminars, enrichment experiences, materials development, conferences, regional networks, and so on. Awards of up to $1 million per year for up to 5 years are envisioned, plus local matching funds. Under the Model Projects stem of this program, institutions propose highly focused activities at the undergraduate level that will improve the access of underrepresented groups to careers in science and technology. Project activities are to be based on science and mathematics experiences. In both cases, NSF is committed to disseminating the results of these efforts well beyond the bounds of the individual institutions that conduct the programs, to have a real impact on the educational infrastructure.

Engineering Education Coalitions Program. A second notable and large-scale NSF program of recent vintage is the Engineering Educational Coalitions Program (*65*). This program supports the design, development, and testing of innovative approaches for increasing the effectiveness of the undergraduate engineering learning experience. Proposals are sought from coalitions of engineering schools that meet minimum criteria for the aggregate number of B.S. engineering degrees awarded, both in total and in underrepresented groups. Again, the coalition concept is designed to impact significant numbers of students and to foster the diffusion of the programs developed. The Pennsylvania State University is a member of one of the two coalitions funded in the first round of awards, the Engineering Coalition of Schools for Excellence in Education and Leadership (ECSEL). The focus of the ECSEL program is to spread instruction in design concepts and methodology throughout the undergraduate engineering program rather than to limit design instruction to the last year. This will help to alleviate the commonly noted problem that engineering students often spend 2 years in college before they take any engineering courses of significance, which should improve retention and student motivation. The ECSEL activities also include elements designed to improve the students' communication, team-building, and leadership skills.

These two programs are representative of NSF's current initiatives in mathematics, science, and engineering education. The Foundation has become markedly more proactive in these areas and more attentive to spreading the results of their programs throughout the United States. They also continue to offer their traditional strong programs of support for individual projects, individuals, and institutions in scientific research and education, and linkages between them.

Department of Energy

The Department of Energy (DOE) is currently providing funding to several initiatives that promote the study of mathematics and science (*66*). To promote the study of mathematics and science at the secondary school level, the DOE is funding "The Explorers Program." This program is a collaboration between two Chicago-area DOE units, the Chicago public school system, and other public institutions, universities, and industries, and is expected to benefit 10,000 Chicago-area students. Other DOE activities include funding for the development of a combined 5-year curriculum at Fort Valley State College in Georgia and the University of Nevada at Las Vegas. Students graduating from the 5-year curriculum will earn both a mathematics and an engineering degree. DOE also sponsors a summer internship program for students, at the University of Tennessee, who are studying to be mathematics or science teachers.

National Aeronautics and Space Administration (NASA)

The National Aeronautics and Space Administration supports several endeavors to promote interest in mathematics/science/engineering. The "Recruitment and Retention Program for Excellence in Engineering" combines scholarship, mentor, and cooperative education activities (*67*). Freshman engineering students receive scholarship support. Upperclassmen, who have participated in the scholarship program, function as "mentors" to the freshmen. An additional aspect of the program is the participation of the scholarship recipients in NASA co-op assignments during the later part of their undergraduate program.

NASA also sponsors the Summer High School Apprenticeship Program (SHARP) (*67*). This pre-college program for underrepresented minority students involves an 8-week summer employment experience at various NASA locations. During this 8-week period, scientists, engineers, and other technical specialists function as mentors to the participating students.

During 1987, Congress approved the establishment of the National Space Grant College and Fellowship Program and, in 1990, three institutions were designated as space grant universities: The Pennsylvania State University, The Massachusetts Institute of Technology, and The University of Washington (*68*). The purpose of this program is to encourage more students to consider careers in aeronautics, space technology, and related fields; and to increase public awareness and support of U.S. aerospace programs. Specific activities of the space grant universities include fellowship awards for qualified students, initiation of a university course in space technology for non-science majors, initiation of a program for college professors in science and education, and sponsorship of a space academy for academically outstanding high school students that includes both classroom instructions and laboratory experience on various NASA-supported projects at the university.

Industrial Organizations

Westinghouse Corporation (69)

The Westinghouse Foundation makes charitable contributions to nonprofit organizations, primarily in communities where the Westinghouse Corporation has a presence. Support for education is central to the corporation's contributions program. Higher education is the Foundation's primary interest, especially in the engineering, applied science, and business disciplines. Preference is given to institutions with accredited 4-year programs. Emphasis is placed on programs that promote innovative academic or curriculum development initiatives and new teaching methods. Special attention is given to projects where opportunities are provided for minority, women, and disadvantaged students.

In 1977, the Westinghouse Steering Committee for Minority Communications was formed to develop communication bridges and strengthen relationships between Westinghouse and minority communities throughout the United States. The committee places a special focus on communicating to minority youth an awareness of career opportunities in engineering, science, and technology, and the interest Westinghouse has in more minorities entering these fields (*70*).

The committee has sponsored a variety of successful and far-reaching programs that carry the committee's objectives into minority communities and impact millions of people (*70*).

Awarding-winning advertising campaigns have communicated the opportunities created by engineering careers to potentially 211 million people. In response to a toll-free telephone number placed in the ads since 1982, more than 52,000 people have requested additional information about engineering (*70*).

The Foundation also encourages educational programs that strengthen public schools through enhanced learning and teaching experiences, especially in science, mathematics, and economics education, or meet the needs of special populations, including the young, older persons, the gifted, the handicapped, minorities, and women.

Among the programs that the Foundation supports is the 5-week Minority Engineering Summer Research Program at Vanderbilt University. This program helps high school seniors get a head start by exposing them to different specialties, teaching them stress-coping techniques, and providing a preview of academic life. Students learn hands-on scientific investigation and participate in enrichment activities, seminars, field trips, academic courses, and workshops.

Another program supported by the Foundation is the Women in Engineering Initiative (WEI) at the University of Washington-Seattle. This program addresses the underrepresentation of women in engineering. Its goals include attracting women to and retaining them in engineering, removing barriers that deter women from successful careers in engineering, and providing support programs such as tutoring, mentoring, and counseling.

Since its inception in 1988, WIE has documented a 2 percent increase in enrollment, from 15 percent to 17 percent. In addition, 40 students who considered dropping out of the engineering program were retained. An important measurement component, a computer-based system, tracks female students from program entry through career development and provides valuable insight and research data on women in engineering (*69*).

The Foundation support during 1989 for 139 educational programs totaled $3,865,967 (*69*).

Rockwell International (71)

Rockwell International, a high-technology company that recruits an average of 1,000 science and engineering graduates each year, is especially concerned with poor student performance in mathematics and the sciences. Rockwell is responding to this by supporting more than 200 programs aimed at students from kindergarten through university graduate levels. Rockwell aims to achieve, through these programs, the following three goals:

1. Mathematics and science teacher enhancement through: (a) teacher grant programs to recognize and reward innovative teaching practices and promote their replication by others; (b) training programs to update the knowledge and skill of mathematics and science teachers; (c) special mathematics and science teaching delivery systems to help teachers stimulate student learning and motivate students to pursue higher education and careers in mathematics and science; (d) teacher internships at Rockwell facilities; (e) curriculum development advisors for elementary and secondary education levels, particularly in the areas of mathematics and science; and (f) resources and support for teachers to enhance their knowledge on the application of mathematics and science to industry needs.

2. Increased student interest and achievement in mathematics and science through: (a) sponsorship of programs to inform students of career opportunities that draw upon the skills learned in mathematics and science education programs; (b) mathematics and science student competition programs; (c) student internship programs to expose students to the practical application of mathematics and science; (d) advanced career training programs that allow students to gain hands-on experience in industry as an incentive to gain a high school degree and pursue higher education; (e) scholarship programs; and (f) programs to provide intensive remedial teaching to at-risk students.

3. Improvement of the education process and teaching methodologies via: (a) underwriting of, and participation in, projects that seek to address the design or redesign of the educational process within the schools; and (b) underwriting selected research to develop a more creative and cohesive curriculum and more effective teaching methodology.

Examples of the programs Rockwell supports are: a *Teacher Improvement Program (TIP),* which is designed to inject new life into sagging science and mathematics curriculum; an *Advanced Career Training (ACT)* program through which high school seniors are offered a head start in the business world; and a *Youth Motivation Program (YMP),* which is an educational opportunity that supplements classroom learning to motivated high school students. In *I Have a Dream Foundation,* Rockwell volunteers serve as mentors to combat the disturbing trend of school dropouts. And, finally, a *Graduate Fellowship Program* is directed toward students who are seeking university teaching careers rather than industry employment after completing their studies. Rockwell provides grants for 23 students at 18 universities.

Rockwell calls upon the volunteer efforts of its employees and retirees to help in these programs. In addition to the foregoing activities, Rockwell has launched a multimedia advertising campaign to encourage individuals and companies to support schools in their communities.

In reviewing the goals and activities of Westinghouse and Rockwell, an emphasis on the importance of education partnership between industry, business agencies, and educational systems was very clear. There are many good programs both in their design and objectives that will fail for one critical reason: lack of funds.

Resource Organizations

Women Resource Organizations

Society of Women Engineers (SWE) (*72*). SWE is a nonprofit educational service organization of graduate engineers and men and women with equivalent engineering experience.

SWE's specific objectives are to inform young women, their parents, counselors, and the general public of the qualifications and achievements of women engineers and the opportunities open to them; to assist women engineers in readying themselves for a return to active work after temporary retirement; and to encourage women engineers to attain high levels of education and professional achievement.

SWE was founded in 1949–1950 when small groups of women engineers started meeting in New York, Boston, Philadelphia, and Washington, D.C. The Society was incorporated in 1952. SWE student sections have been chartered at more than 240 colleges, universities, and engineering institutions throughout the United States.

The society's activities include administration of more than 40 scholarships annually in two national scholarship programs; sponsorship of national conferences that address issues and concerns of women in engineering; administration of surveys of women graduate engineers, followed by publication and distribution of the results of these surveys in "A Profile of the Woman Engineer"; and publication of an informative magazine, *U.S. Woman Engineer.*

Math/Science Network (*73*). The Math/Science Network is a nonprofit organization that promotes the participation of young girls and women in mathematics, science, and engineering. Officially established as a membership organization in 1978, the organization has received grants from the Carnegie Corporation, the National Science Foundation, NASA, and others to conduct several programs and activities, including:

1. *Expanding Your Horizons* (EYH) conferences. During 1990, EYH conferences were conducted in 80 locations in 21 states. The goal of these conferences is to encourage young women to continue their studies of mathematics and science in high school, so that they will be prepared to pursue science-related careers. Since the first conference was conducted in 1976, more than 164,000 young women and 25,000 adults have participated in these conferences. During 1989, approximately 22,400 young women (half of them in 7th and 8th grade) participated in these conferences. Typically conducted at a college campus on a Saturday, the conference includes speakers, a career fair, and workshops.
2. Distribution of a videotape, entitled "Nothing But Options," that profiles five young career women.
3. Maintenance of a database to provide information on women's studies programs, resource centers, support groups for women in business and industry, and foundations supporting women and science.
4. Maintenance of a Resource Center containing a collection of science and mathematics equity materials (reports, brochures, videotapes, and the like).

Ethnic Minority Resource Organizations

Society of Hispanic Professional Engineers (*74*). Society of Hispanic Professional Engineers (SHPE) was founded in Los Angeles, California, in 1974 by a group of engineers. Their objective was to form a national organization of professional engineers to serve as role models in the Hispanic-American community.

SHPE is working to increase the number of Hispanic-Americans entering the engineering and science fields by developing an effective early outreach recruitment mechanism to advise and encourage Hispanic-American students to pursue higher education in those fields. SHPE is also developing a retention program at the university and college level to assist students completing their engineering degree programs. In addition, it provides scholarships and educational grants to students, and supporting programs that enhance the Hispanic student's educational goals.

SHPE has a strong and independent network of professional and student chapters throughout the United States.

The Advancing Careers in Engineering (ACE) Program is one of the major programs sponsored by SHPE. Its objectives are to aid in retention at the university and college level; encourage youth at the high school, junior high, and elementary school levels in educational pursuit; and to develop quality graduates through technical, interpersonal, and communications skill building.

American Indian Science and Engineering Society (75,76). American Indian Science and Engineering Society (AISES), founded in 1977 by concerned Native-American individuals, is a nonprofit professional and educational organization that seeks to significantly increase the number of Native-American scientists and engineers in the nation and to develop technologically informed leaders within the Native-American community.

AISES begins working with Native-American students as early as elementary school to strengthen their educational background in mathematics and science and to prepare them for the academic and cultural pressures of life away from home. At the college level, AISES provides scholarships, mentoring support, and leadership training to further prepare Native-American students for successful science and engineering careers.

Among AISES' activities are a mathematics and science enrichment summer camp for junior high school students (220 students participated in the 1989 summer camp); a high school mathematics enrichment program for junior high and high school students (a new program was begun in 1989); a teacher training program for elementary and secondary Native-American school teachers (to date, 550 teachers have been trained through this program); and publication of a national quarterly magazine, *The Winds of Change.*

National Association of Precollege Directors. The National Association of Precollege Directors (NAPD) is a nonprofit organization consisting of 26 member programs whose mission and program efforts are directed at increasing the pool of students who pursue engineering and mathematics-based college study. Students who participate in NAPD programs are from ethnic groups that are historically underrepresented in the science and engineering professions: African-Americans, Hispanic-Americans, and Native-Americans.

The NAPD was founded in 1978. Since its origin, NAPD membership has grown from 6 to 26. In the 1989–1990 school year, close to 50,000 students in more than 1,000 schools from grades 6 through 12 were enrolled in NAPD programs.

All NAPD programs share one important quality: a strong collaborative relationship among the university, industry, and participant school systems which they serve. This organizational relationship allows NAPD programs to share and complement institutional and personal resources, which greatly increases their leverage and effectiveness in reaching students and teachers in a given school system. NAPD programs operate in 30 states and have direct access to the resources of colleges and industry. Over 113 universities and 291 engineering employers collaborate with NAPD in offering participating students real world project applications that greatly enhance the learning of mathematics and science.

Of the 26 pre-college programs that are part of the NAPD—including the Academic Champions of Excellence (ACE), the Buffalo Area Engineering Awareness for Minorities Program (BEAM), California-Mathematics, Engineering, Science Achievement (CA-MESA), New Jersey Institute of Technology (NJIT), Southeastern Consortium for Minorities in Engineering (SECME), and Texas Alliance for Minorities in Engineering (TAME)—several have many years of experience and offer a mix of sciences and support, while others are more recently established. The activities offered to student participants are both academic and experiential, in-school, and extracurricular. NAPD's programs (*77*) offered to students include daily in-school mathematics instruction, hands-on science and technology projects, tutoring and mentoring, field trips, summer programs, and teacher training workshops. Two examples of NAPD member programs, SECME and TAME, are described in the following discussion.

Southeastern Consortium for Minorities in Engineering (78,79)

The Southeastern Consortium for Minorities in Engineering (SECME) was established in 1975 by the deans of engineering from six universities for the purpose of increasing the number of underrepresented minorities in engineering professions. Presently, SECME's network links 27 universities and 60 corporations to serve more than 24,000 students in 225 schools throughout 7 southeastern states.

SECME programs operate within the existing educational structure at the junior and senior high school levels. The aims of these programs are to identify and place minority students with academic potential in college preparatory courses during their early years in secondary school; to enrich college preparatory courses—particularly mathematics, science, and language arts—with supplementary curriculum materials; to develop guidance programs that give students an awareness of opportunities in engineering and other mathematics and science-based fields and assist them in making career choices; to provide role models who can demonstrate that careers in technical fields are obtainable with the proper preparation; and to encourage qualified students to enroll in engineering colleges.

The programs are administered by a school-based team of principal, counselor, and mathematics and English high school teachers. This team is trained at an intensive 2-week summer institute that is also sponsored by SECME. The participants are given an overview of engineering as a profession and an awareness of the opportunities for minorities in engineering. They are introduced to curriculum enrichment materials and, with assistance from engineering faculty consultants, they develop implementation plans for their local programs for the coming school year.

To date, SECME has trained 1,200 teachers and counselors.

Pre-college programs in other areas of the country are now sending their teachers to the summer institutes to be trained by SECME, and SECME serves as a consultant for other pre-college programs in designing and implementing similar institutes.

SECME's accomplishments over the past years include 12,000 SECME students, who graduated from high school in the years 1983 to 1987, 85 percent of whom planned to continue on to college. Nearly 50 percent of those continuing to college entered engineering, science, medical, or mathematics-based fields. SECME students' SAT scores exceed the national African-American SAT averages by over 200 points.

Texas Alliance for Minorities in Engineering, Inc. (80)

The Texas Alliance for Minorities in Engineering, Inc. (TAME) was founded in 1975 by Texas industrialists and educators to promote minority students' interest in the engineering profession. It is now operating at 22 chapters that reach approximately 3,500 Texas junior high and high school students each year. Each TAME chapter mobilizes the resources of local industries, universities, and public schools in the engineering and scientific fields. Among the programs TAME offers are career conferences with leading engineers; summer jobs in sponsor companies; college scholarships; assistance to selected public schools; development and definition of preengineering curricula; and EXPO, a mobile trailer exhibit.

National Action Council for Minorities in Engineering, Inc. (81,82)

National Action Council for Minorities in Engineering, Inc. (NACME) is a nonprofit corporation dedicated to increasing the number of African-Americans, Hispanic-Americans, and Native-Americans who enter the engineering professions.

For more than 15 years, NACME has provided leadership and coordination for a growing network of institutions that are committed to its goals — school systems, local programs, universities, corporations, professional societies, and minority groups — collectively known as the minority engineering effort. Through programs that are based firmly on applied research, and with funding from more than 170 major donors, NACME provides scholarships and grants, develops pre-college and university intervention programs, and creates and disseminates original materials that promote interest in engineering careers.

NACME's Incentive Grants Program (IGP) is the Nation's largest privately supported scholarship fund for minority engineering students. Specifically designed to foster university commitment as well as individual achievement, IGP has provided more than $33 million in student financial aid. Since the program began in 1975, NACME scholars account for more than 10 percent of the minority students in the United States who have earned their engineering degrees.

To prepare students for the academic rigors of engineering school and to encourage excellence among those enrolled, NACME Field Services develops and implements both pre-college and university interventions. Through grants, technical assistance, professional training of program directors, and a host of consultant services, NACME tailors new initiatives to meet local needs and helps strengthen programs that already provide valuable services to their communities.

Educating Tomorrow's Engineers: A Guide to Precollege Minority Engineering Programs (82) and *Academic Gamesmanship: Becoming a "Master" Engineering Student (83)* are two examples of NACME's publications. The first catalogs 107 educational initiatives throughout the United States that are working to increase the number of minority students with the academic and motivational preparation to enter engineering and other technical fields of study. It is an excellent resource document, complete with names, addresses, and telephone numbers of program contacts. The second publication is a clear and concise guide, providing an excellent overview of the issues and concerns facing engineering students.

Philadelphia Regional Introduction for Minorities to Engineering (25)

Founded in 1973, the Philadelphia Regional Introduction for Minorities to Engineering (PRIME) program is a pre-college partnership of Philadelphia-area businesses, government agencies, colleges and universities, professional associations, and parent groups, all working together to identify and prepare minorities for careers in the technical and scientific professions. PRIME offers its programs to junior and senior high school students in Greater Philadelphia, Southern New Jersey, and other parts of the Southeastern Pennsylvania region. These students are recommended by teachers and must have A's and B's in mathematics and science. Capable minority students, identified as early as 7th grade, participate for 5 years in specialized and supplementary activities in mathematics, science, and communications to prepare them for mathematics- and science-based careers. Through development of industry-supported pre-college programs, PRIME provides aid to school districts to develop curricula that prepare students for technical careers. It coordinates activities for students at the secondary and college levels during both the academic year and the summer, activities that include model bridge building and egg drop competitions. PRIME serves as a resource center to minority students, and supports efforts to increase the number of minority students entering and completing technical-college degree programs.

PRIME offers a week-long summer institute to update teachers' skills and to illustrate how mathematics and science can be applied to real-world technology. It is estimated that 35,000 students have participated to date.

Chicago Careers for Youth (72)

An example of educational partnership is the career guidance program Chicago Careers for Youth (CCFY), which was started in 1976.

Through this program, role models from the business world interact directly with students in grades 6 through 12 to help with their career preparation. The program introduces the youngsters to 16 broad interest clusters. In 6th grade, the students hear one speaker each month from the first eight clusters, and in the 7th grade, they hear from the other eight. In addition to the role model speakers, videotapes, booklets, and wall charts are used. After the students are exposed to all of the clusters, they choose the one that best matches their interests. In the 8th grade, each student attends a specific career day program to learn how they might prepare for the career of their choice.

The next step is choosing a high school that offers cluster-specific courses in addition to traditional subjects. The program does not push students to attend college; it is up to the student after graduating from high school to choose a college or non-college track. Among the 16 clusters that the students are introduced to are: civil and environmental engineering, transportation, agriculture, and education.

Chapter 3

PRACTICES USED BY OTHER PROFESSIONAL DISCIPLINES

Four engineering and science professional societies responded to the request for information regarding programs and activities that they support or promote to increase awareness in their profession. These societies are the American Society of Mechanical Engineers (ASME); the Society for Mining, Metallurgy, and Exploration, Inc. (SMME) (formerly The Society of Mining Engineers); the Institute of Industrial Engineers (IIE); and the Institute of Electrical and Electronics Engineers (IEEE). A summary of the programs and activities supported or promoted by each professional society is presented in Appendix E.

EFFORTS OF OTHER ENGINEERING AND SCIENCE DISCIPLINES

The four professional societies report programs and activities similar in nature to the current efforts to promote civil engineering, including videotapes, brochures and flyers, booklets, posters, participation in career days, invitations to high school students and teachers to attend professional chapter meetings, participation in Engineer's Week programs at high schools, and science fairs.

The American Society of Mechanical Engineers (ASME) distributes several videotapes, booklets, and brochures targeting students in grades 6 through 12. One videotape, "It's Not too Late," targets grades 6 through 9, while a second videotape, "Mothers of Invention," targets young women and minorities in grades 8 and 9 by describing the contributions of women and minorities to the engineering profession. ASME has a variety of videotapes, booklets, and brochures that target the senior high student. These materials provide these students with information regarding the types of work the mechanical engineering professional performs. Several of these materials discuss the difference between mechanical engineering and mechanical engineering technology.

The Society for Mining, Metallurgy, and Exploration, Inc. (SMME) provides scholarships and loans. A related society, The Women's Auxiliary to American Institute of Mining, Metallurgical, and Petroleum Engineers (WAAIME) promotes the "Engineers for Tomorrow" program. The purpose of this program is to stimulate interest among secondary school students in mineral science careers. Another society related to SMME is the Mineral Information Institute. The purpose of this institute is to develop and distribute educational materials regarding mineral science for students in primary and secondary schools. For the primary schools, the institute distributes "Mining, Minerals, and Me." For the secondary schools, the Mineral Information Institute has a program, entitled "Energy, Resources, and Environment," that can be incorporated into the science curriculum. The Institute also functions as a clearinghouse for publications and films that can be borrowed or rented by the primary or secondary schools for instructional purposes.

EFFORTS OF THE AGRICULTURE-RELATED PROFESSION

The information provided below was obtained from faculty and academic administrators in the Agricultural Engineering discipline at The Pennsylvania State University. The experience in enrollment and degrees awarded in agricultural engineering tends to follow the trends in agriculture rather than those in engineering. Nationally, the number of bachelor of science degrees awarded annually in agricultural engineering has dropped by 50 percent over the past decade. Aggressive recruiting by individual academic departments has been necessary to combat this trend. This typically involves immediate response to any students who exhibit an interest in the field, and personal contact by faculty and department heads. The relatively small number of prospects and the low student/faculty ratios of these programs, today, make this approach workable.

The principal difficulty in recruiting is the portrayal of an accurate image of agricultural engineering. Most students, and the general public, believe that graduates will work as farmers. In reality, there are many career opportunities outside of production agriculture, in areas such as food processing, development of machinery and equipment, soil conservation, land management, and technical sales. Thus, most public information and recruiting materials emphasize this diversity of career opportunities.

The most visible national effort of this type is the "Energizing the Green Machine" campaign. A brochure titled "Energize the Green Machine," produced by Food & Agriculture Careers for Tomorrow, of the School of Agriculture at Purdue University, and co-sponsored by the U.S. Department of Agriculture, is directed toward minority recruitment, although it provides and presents information for the population as a whole. This campaign features brochures and a videotape that highlight careers in food production, natural resource management, and even the development of agricultural systems for space habitats.

Currently, 23 universities are affiliated with Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS), a national resource organization. Apart from the foregoing efforts, there is little else available from national sources. Most recruiting is the responsibility of local initiatives, utilizing ties to the State 4-H and Future Farmers of America (FFA) organizations and the efforts of the agricultural extension services.

EFFORTS OF THE HEALTH CARE INDUSTRY

The Health Care Professions

The Hudson Institute predicts that the professions related to providing health care will experience a 53 percent rate of growth between the years 1985 and 2000 (*2*). As with engineering, segments of the population are underrepresented in these professions, although in several instances, improvements have been achieved. Since 1979, the enrollment of women in medical schools has increased from 25.4 percent to 36.1 percent of the total enrollments (*84*). In part, this is because of women's increased interest in pursuing medicine over the more traditional health career of nursing. A survey by Grossman et al. determined that high school females with an interest in the health care professions currently select medicine over nursing by a 5 to 4 ratio (*85*). The enrollments in medical school for African-Americans and Hispanic-Americans during the last decade have remained relatively flat. Currently, African-Americans account for 6.3 percent and Hispanic-Americans account for 5.5 percent of medical school enrollments (*84*).

The relative stagnation in the African-American and Hispanic-American representation in the medical schools has persisted despite recruitment and retention programs now in place. Tysinger and Whiteside provide a review of the programs practiced by the professional schools (*86*). They note that these programs were initiated in the late 1960's to respond to the financial, academic, and psychological needs of the minority student. The primary recruitment practice is summer enrichment programs. These programs, typically 3 to 10 weeks in duration, are designed for minority freshman and sophomore college students. Their intent is to provide science and academic instruction and to motivate the students to pursue careers in the health professions. As of 1986, 50 such programs were in existence.

Retention programs include prematriculation programs, designed to smooth the transition from undergraduate school to professional school, and academic-year programs including orientation classes, tutoring services, advising, and counseling services. The prematriculation programs are voluntary and range from 2 to 10 weeks in length. Their purpose is to integrate science and academic skills.

The Health Careers Opportunity Program (HCOP), administered by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services, is a major source of funding for the recruitment and retention programs listed above and is targeted for disadvantaged individuals (*87*). Since 1978, approximately 400 different HCOP programs have received nearly $173 million to support their endeavors. The programs make grants to and enter into contracts with professional schools (schools of medicine, osteopathic medicine, public health, chiropractic, dentistry, and the like) and other health or educational entities to execute programs that assist individuals from disadvantaged backgrounds to enter and graduate from health professional schools. Currently, 156 programs actively provide assistance to 13,000 high school, college, graduate, and professional students (*88*). Seventy-six percent of these students are African-American and 16 percent are Hispanic-American.

Two specific examples of programs designed to recruit and retain individuals from underrepresented groups into the health care professions are the Minority Advanced Placement Program (MAPP) and the Graduate Minority Health Careers Institute (GMHCI) at The Pennsylvania State University. MAPP is a free summer academic program for high school students who possess strong academic abilities and have expressed an interest in pursuing a degree in the health career professions. Available to disadvantaged students from minority backgrounds (African-Americans, Hispanic-Americans, Asian-Americans, and Native-Americans), MAPP consists of two components. In the first component, the student attends a series of seminars on study techniques, writing skills, and computer skills. The student also receives career counseling and attends lectures presented by minority health professionals. The second component of the program permits the student to enroll in an undergraduate summer course. The tuition is free, and the credits earned may be applied toward the degree requirements.

The Graduate Minority Health Careers Institute (GMHCI) is a 5-week summer program available to disadvantaged students who have completed their junior year in college and have expressed an interest in pursuing a career in the health professions. The program is suited for individuals considering such professions as speech therapy, health education, hospital administration, or other health professions. The program involves both seminar and practicum experiences to assist in career planning and orientation to graduate education.

The Nursing Profession

The American Association of Colleges of Nursing reports that by the year 2000, there will be one-half as many nurses with baccalaureate degrees as needed nationwide (*89*). Grossman et al. attribute part of the current shortage of nurses to the fact that women, who have historically constituted the traditional pool of nurses, now increasingly pursue the traditional male professions of medicine, law, and engineering (*85*). In 1988, Grossman et al. conducted a survey of 300 high school students to determine their perception of nursing as a career (*85*). The survey determined that high school students were generally aware that nursing involved providing health care activities. However, the high school students lacked information on the growth and development opportunities available in nursing, especially in such areas as administration and management. The males in the survey had a negative view of the profession, viewing nursing as a female profession. The study concluded that the nursing profession needs to conduct a public relations campaign to overcome the current negative image of nursing, and specifically to improve the image conveyed to the underrepresented male group. The study advocated the use of nurses as role models to high school students.

Projects currently underway to alleviate the nursing shortage include the National Commission on Nursing Implementation Project (NCNIP). This project is currently conducting a media (radio and television) campaign to reach out to individuals interested in the nursing profession and a public relations campaign to improve the image of nursing. The Robert Wood Johnson Foundation and The Pew Charitable Trusts are sponsoring a recently implemented, 5-year, $26.8-million program to find innovative solutions to the nation's shortage of nurses. Twenty hospitals are expected to participate (*90*).

EFFORTS OF GOVERNMENTAL ORGANIZATIONS

The Military Establishment

Military Science. The information provided below was obtained from academic administrators in the Military Science discipline at The Pennsylvania State University. During and immediately after the Vietnam War, society's regard for the military declined drastically, which made recruiting very difficult. The public's view of the military has improved in recent years, which has made recruiting somewhat easier. Nevertheless, Reserve Officers' Training Corps (ROTC) program heads still identify recruiting as their "toughest" assignment.

The U.S. Army basically uses every method of public information and advertising, including brochures, magazine and newspaper displays, radio, television, and direct mail, all developed under the guidance of marketing consultants. The effectiveness of this effort is evident; "Be all that you can be" has become part of the vernacular. ROTC programs have benefited from the recruiting conducted for all aspects of military service. The military is basically looking for the same types of individuals as are engineering programs. Their ideal ROTC recruit is the high-tech engineer. Their strategy is to convince large numbers of students to at least try the program, expecting that the attrition rate is likely to be high. A principal technique is to participate in high school career day programs, where the goal is to motivate juniors and seniors to apply for 4-year scholarships offered by the ROTC program. Personal contact by current cadets with other college students has been effective as an on-campus recruiting tool. Once students are enrolled, considerable effort is directed toward retention.

Recruiting women into the ROTC program has not been a particular problem; normal recruiting seems to bring in sufficient numbers without extra effort. Finding ethnic minority students, however, is as difficult as it is in engineering. The Army has attacked this problem by supporting the historically black colleges and universities. They also have the "Green to Gold" program to assist enlisted personnel, where minorities are heavily represented, in completing a college degree and enrolling in Officer Candidate School. Also, all Army advertising always features participation of women and ethnic minorities. In summary, the constant media presence, the innate desire of significant numbers of students for military careers, and the availability of scholarships and specialized training all seem to be working to maintain ROTC enrollments.

Federal Aviation Administration

Responding to the dramatic growth predicted for the aviation industry through the end of the century, the Federal Aviation Administration (FAA) of the U.S. Department of Transportation initiated the "Airway Science Program" in 1982 (*91*). The purpose of this program is to assure a supply of talented individuals for occupations in areas such as air traffic control, computer science, electronics, aircraft operations, safety occupations, and aviation maintenance management. This program exists as an educational partnership between the FAA and the academic community at the undergraduate level. The Airway Science curriculum, consisting of a core subject area and five areas of concentration, has been initiated by numerous institutions of higher education, including several *H*istorically *B*lack *C*olleges and *U*niversities (*92*). The core subject area includes studies in liberal arts, mathematics and science, computer science, and management. The five areas of concentration are: Airway Science Management, Airway Computer Science, Aircraft Systems Management, Airway Electronic Systems, and Aviation Maintenance Management.

The role of the FAA in this program includes curriculum development contracts with the participating higher education institutions to assist in the implementation of the program, and the employment of a number of qualified graduates each year. The program is headquartered in Washington, D.C., and also has a coordinator at each of nine FAA regional offices throughout the United States.

Chapter **4**

CAREER CHOICE DECISIONS

To assist in the development of the focus group protocols, a literature review was performed to synthesize the findings of the studies and writings on the nature of mathematics/science/engineering career choice decisions. The purpose of this literature review was not to comprehensively examine all information on this subject, but, instead, to provide sufficient insight into the factors that influence the career choice decision model of young people to provide guidance on how to conduct the focus group sessions. Most of the writings and studies reviewed addressed the career choice decision from the broader perspective of mathematics and science or engineering. However, several studies specifically addressed the attitudes toward and perception of civil engineering as a career alternative. This section presents the highlights of this synthesis regarding career choice decisions and the factors influencing the career choice decisions of women and minority groups.

LITERATURE REVIEW

Knowledge, Attitudes, and Perceptions of Civil Engineering as a Profession

The Naidus Group conducted two focus group sessions with high school and college educators for the American Society of Civil Engineers (*39*). The purpose of these sessions was to explore how the Society could assist in attracting qualified individuals to the civil engineering profession. The key findings of this study indicated that both college and high school educators reported a perception among students and faculty that the civil engineering profession ranks below the other engineering specialties in terms of financial rewards, social status, academic requirements, and job satisfaction. Specifically, the focus group participants indicated the perception among their students that civil engineering was not a "high-technology" engineering profession, nor did it offer the salary growth potential of the other engineering professions. College and high school educators also reported a serious lack of understanding among students and faculty about what civil engineering involves and what career opportunities exist for civil engineers.

College educators felt that a majority of incoming engineering students have already identified engineering as a chosen profession, and that most of them have also identified a specific engineering specialization. Both college and high school educators stressed the concern that many students in the junior and senior years of high school are not adequately prepared in mathematics and science for entering engineering schools.

Additionally, the high school focus group indicated that the ability to be a problem solver was an individual trait that differentiated the engineering-oriented students from the mathematics and science students. Also, during the sessions, the ASCE videotape, "Is Civil Engineering for You?", was reviewed. The panel criticized the videotape for its blue-collar approach to civil engineering instead of its introducing civil engineers as well-trained and highly qualified professionals.

The failure to present a satisfactory public image of civil engineers, and transportation engineers specifically, has been identified by others. Hoel et al. note that for civil engineering to compete with other professions for individuals of similar abilities, an increased awareness of the opportunities transportation offers is required (*36*). Noting that the children of professional parents are typically educated in the liberal arts, Disario advocates the need to broaden engineering education to include studies of public service (*93*). In this way, the service that engineers provide to the public will be better identified by young people, thus enhancing the image of the profession. Stringer has editorialized the need for the civil engineering profession to heighten the public's image of civil engineers, to advertise the specialties in civil engineering, and to become better marketers (*94*).

In line with the comments above, the Institute of Transportation Engineers (ITE) (*5*) has discussed the need to improve the public image of civil engineering and transportation engineering, the average entry-level salaries of civil and transportation engineers, and the professional and social status of civil engineering and transportation engineering.

The occupational description for civil engineering, as presented in the *Occupational Outlook Handbook* published by the U.S. Department of Labor, is an example of the image difficulties plaguing the civil engineering profession. While most of the engineering specialties described in the publication indicated that the employment of their engineers was in higher level administration and management areas, the civil engineering description appears to limit the civil engineer to positions ranging from supervisor of a construction site to city engineer (*95*).

Knowledge, Attitudes, and Perceptions of Women in Mathematics, Science, and Engineering Career Choice Decisions

Currently, women constitute 5 to 7 percent of the estimated 1.6 to 1.7 million engineers in the United States (*96,97*). Although this figure is low with respect to the female representation in the population, significant improvement has been achieved since 1972, when women constituted only 0.8 percent of all practicing engineers. Numerous studies and surveys have been conducted regarding the nature of the career choice decision, and on the positive and negative influences on women toward careers in engineering and civil engineering.

The Cooper Union has conducted surveys of both women engineering students and practicing women engineers to gain insight into their motivations, expectations, and aspirations. They surveyed approximately 4,000 women engineering students as to their primary reasons for pursuing engineering careers (*98*). The primary reasons given were: (1) the expectation to perform interesting work, (2) the challenge of solving problems, and (3) the expectations for many employment opportunities. Nearly all (98 percent) of these women noted a perception that an engineering career would provide opportunities to learn and grow. Furthermore, 93 percent indicated satisfaction with their decision to study engineering.

The Cooper Union has also completed a survey of 4,000 women currently employed as engineers in the United States (*99*). Eighty-seven percent of the respondents indicated that their job assignments were interesting and that their salaries met or exceeded their expectations. Though approximately half of the women in this study were married with families, only 4 percent of the respondents noted that their work created a serious conflict with family responsibilities.

Interviews of practicing women engineers conducted by Carter and Kirkup found that the women selected engineering over mathematics and science pursuits because they perceived engineering as a broader alternative to the more academic or theoretical careers in mathematics and science (*100*). These women indicated the enjoyment of the variety of tasks and responsibilities their engineering careers presented. They also cited the opportunity to apply mathematics and science to solve day-to-day problems as a primary reason to pursue engineering, as opposed to a perception of being locked into a teaching profession by studying mathematics or science.

The findings of the above surveys and interviews indicate general satisfaction with engineering for women who either are members of the profession or have long since chosen this career path. The themes of opportunity, problem solving, variety, and responsibility are foremost. However, the literature does identify several factors that are obstacles to women entering an engineering career path, accounting for the low percentage of representation.

The Office of Technology Assessment attributes this underrep-

resentation to (*7*):

1. The legacy of discrimination toward women.
2. Differential treatment applied on the job.
3. Female socialization patterns that discourage women from pursuing engineering as a career.
4. The persistent societal expectation that women will continue to assume the major role in housekeeping and child rearing.
5. The lack of role models and early exposure to the field.

Engineering is in direct competition with the "traditional" as well as the "nontraditional" professions for the pool of available women making a career choice. Examples of the traditional professions for women are teaching or nursing, which provide to young women a large and visible role-model population with which they can identify. Examples of nontraditional professions that have obtained relative success in attracting women to their professions are medicine, business, and law. In these fields, women currently earn 40 to 50 percent of the degrees conferred (*3*).

Lawyers, doctors, and teachers are highly visible to the public and, therefore, young women have a basic idea about what each of these professions entails and the rewards associated with each job. However, a random poll conducted to determine the public's perception of the responsibilities of the engineer found that 35 percent of the people surveyed had no idea what kind of job an engineer actually performed (*101*). Higher public visibility also results in higher status for a profession in the community. Carter and Kirkup note, "One of the reasons why there are so few women in engineering is that it is not a 'high status' profession like medicine or law. It attracts men because of its connotations with masculinity, but middle class women aim for higher-status professions" (*102*).

Civil engineering must not only compete with the traditional and nontraditional fields for the pool of qualified women, but also with other engineering specialties. With respect to specific engineering professions, women obtain approximately 26 and 28 percent, respectively, of the chemical and industrial engineering degrees conferred. In civil engineering, women constitute only about 15 percent of the annual graduating class (*103*). Currently, of all the engineering specialties, civil engineering has the lowest representation of women, by percentage (*96*). The close relationship between civil engineering and the construction industry may account for part of this gap. Jones has indicated the need for the construction industry to make employment more attractive, especially for women, through convenient office locations, flexible work hours, and maternity leaves (*104*).

The development of adequate science and mathematics skills has also been cited as another cause for the small population of female engineers in the United States. Female students are less likely than men to enroll and persist in advanced mathematics and science courses (*105*). As Hitchner and Tifft-Hitchner have noted, the crucial years for women to get involved in mathematics and science occur early, in grades 4 to 8, not in high school (*106*). It is during these years that teachers, counselors, and parents must encourage their daughters to *actively* participate in mathematics and science classes. Ivey (*107*) states the need for parents, teachers, and counselors to continue this support through junior and senior high school.

An additional influence limiting the representation of women in engineering is the perception that engineering is a masculine profession. During their survey, Carter and Kirkup were frequently confronted with the stereotypes of engineering as being for strong men only or involving a close relationship with machinery (*102*). These stereotypes were especially prevalent in parents, teachers, and counselors. The findings of a survey of women engineers by the Stevens Institute of Technology also indicates parents, teachers, and counselors as primary sources discouraging women from pursuing engineering, believing that engineering is too hard and not a profession to be pursued by women (*108*).

The low number of women in engineering today may have self-perpetuating effects in that it results in a shortage of role models and mentors to encourage and support young women who may be considering engineering careers. Furthermore, the scarce presence of women in engineering results in few role models to influence the parents, teachers, and counselors to believe that engineering is a suitable career choice for women. In the Cooper Union survey of 1989, 80 percent of the women engineering students who responded said they wished they had more female mentors (*98*). Role models in the form of female college faculty members are also in short supply since only 3.4 percent of engineering faculty in this country are women (*98*).

Family culture and upbringing play an important role in career decisions. Parents, who also function as a child's first role models, can either respond positively or negatively toward their daughter's decision to study engineering. A recent study reported that 40 percent of women engineers who were surveyed responded that their primary encouragement for studying engineering came from their parents (*109*). Parents who are college graduates are more likely to understand the value of a post-secondary education and, therefore, present themselves as strong role models to their children. Professional families generally are more supportive of a daughter's nontraditional career choice (*102*). Professional families can be defined as a family in which one or both parents hold college degrees. Half of the female engineers who responded to a survey reported that their fathers had either a bachelor of science or graduate degree.

Another factor that may discourage women from careers in engineering is a concern over gender issues and sexual harassment in the workplace. The Cooper Union found that one-third of women engineers currently working in industry are concerned with sexual discrimination; specifically, they fear that the engineering work of a woman will be judged not on merit but, rather, on gender (*98*). However, gender-related issues are also present in college engineering classes. Depending on their background and cultural upbringing, men hold certain prejudices against women that carry into classes and jobs. Foreign-born faculty and teaching assistants can make engineering very difficult for women, as can an older engineer who has worked with few women before (*97*). This can make a woman feel isolated in the workplace or classroom because of her gender and because men have structured the accepted rules of behavior (*110*). As more women begin to climb the corporate ladder in engineering, a new gender issue that will need to be addressed is how well male engineers will react to female managers (*111*).

Knowledge, Attitudes, and Perceptions of Minorities in Mathematics, Science, and Engineering Career Choice Decisions

The National Science Foundation's report, "Women and Minorities in Engineering," provides a detailed summary of the

statistics regarding the level of precollege preparation and the characteristics of the college-bound seniors for minority groups, specifically the African-American, Hispanic-American, and Asian-American groups (*96*). With respect to the probable career choices of the incoming freshman students in 1987, a summary for selected occupations is given in Table 5.

The data in Table 5 indicate that the college-bound minority populations, specifically the Asian-American population, select engineering at higher percentage levels than the white population. Yet, minorities currently account for only about 2 percent of all practicing U.S. engineers, which is far below their representation levels in the population (*112*). This lower representation is due in part to the lower percentage of the minority population pursuing an academic career, often because of socioeconomic reasons (*113*). An additional factor is the high level of attrition of the minority student in the engineering program. Only about 20 percent of the minority students who begin in engineering ever earn engineering degrees (*11*). Approximately 70 percent of freshman white male engineering students obtain engineering degrees (*10*).

In 1977, the National Research Council (*114*) concluded that the primary factors contributing to high attrition rates are inadequate mathematics and science preparation and inadequate motivation toward an engineering career.

The statistics reported by the National Science Foundation confirm the problem with mathematics and science preparation (*96*). College-bound African-Americans and Hispanic-Americans are less likely to have taken the more advanced mathematics (trigonometry and calculus) and science (physics) courses in high school than their white counterparts. On the other hand, college-bound Asian-Americans are more prepared academically, specifically with respect to their mathematics and science preparation than are college-bound Caucasians.

There are other influences that impact upon this high attrition rate. A survey conducted by Nickolai-Mays and Kammer determined that financial concerns were of primary concern to the African-American student. Secondary concerns included separation from the family and being in a different cultural environment. Additionally, these students expressed concerns about being accepted at home once they received their degrees (*115*).

With respect to the underrepresentation of the minority groups in the engineering profession, the Office of Technology Assessment (*7*) attributes the following factors: the legacy of discrimination; the lack of early educational opportunities for minorities, especially because of economic, social, and cultural factors; the lack of financial support; and the lack of role models and early exposure to engineering.

A report by Rudnick (*116*), on the 1982 survey of incoming freshman engineering technology students at Wentworth Institute of Technology, provides insight into the career choice decisions of the minority student as compared to nonminority students. First, two-thirds of the students, both minority and nonminority, listed *interest* in the field as the primary reason for selecting engineering technology. Few indicated that money was a major motivator. Second, approximately one-half of the minority students indicated that they first considered engineering technology as a career choice three or more years prior to enrolling. Only approximately 25 percent of nonminority students indicated this level of advanced planning. Third, the minority students indicated a higher level of encouragement from teachers and guidance counselors (by a factor of two) as compared to the nonminority students. Both groups indicated approximately equal encouragement from their parents to pursue engineering technology. Interestingly, the nonminority students indicated a higher level of concern with long-range career planning. The minority students were more concerned with the shorter term issues, specifically financial and social.

Table 5. Probable career selections of incoming freshmen for selected occupations, 1987. (Source: Ref. 96)

Occupation	White %	African-American, %	Hispanic-American, %	Asian-American, %
Business Manager	13.2	15.2	11.9	11.4
Computer Programmer	2.1	5.7	2.6	3.1
Engineer	8.0	9.9	10.1	17.1
Lawyer	5.3	7.9	7.1	4.5
Physician	4.0	6.3	8.8	17.0
Science Researcher	1.8	0.8	1.8	2.3
School Teacher	9.1	4.7	5.2	1.6

Summary

In summary, the limited literature review conducted provided the following key inputs to the development of the focus group protocols:

1. *Interest in the field,* as characterized by perception of the profession as involving interesting work with a variety of responsibilities, appears to be a primary influence in the career choice decision.
2. *Parents, teachers, and counselors* play an important role in encouraging young people to pursue engineering. The influence of the teachers and counselors may be more important for the minority population.
3. *For minority students,* financial resources, lack of early educational opportunities, and concern with future opportunities are primary factors affecting the career choice decision.
4. *For women,* female socialization patterns and concerns with future opportunities are primary factors affecting the career choice decision.
5. *Role models* are an important motivational factor.
6. The *image* of the engineering profession, and specifically the civil engineering profession, is poorly defined, among both prospective students and their adult advisors (parents, teachers, counselors).

MARKET RESEARCH STUDY

The principal means of field data collection was a market research study examining how people make career choice decisions and what underlying attitudes and perceptions they have about civil engineering and other professions. A method of qualitative research known as the "depth group" or "focus group" was used. The study was conducted by The Brand Consulting Group, Southfield, Michigan, under the supervision of the Penn-

sylvania State study team and with the assistance of the study consultants located at the field data collection sites. Appendix F in Part 1 contains the full text of the study report prepared by The Brand Consulting Group.

The focus group technique is based on a stimulus and reaction depth interviewing format. It involves approximately 10 people sitting in discussion with a highly trained senior researcher who acts as moderator. The moderator is highly experienced and skilled at stimulating and probing to uncover the participants' insights. Questions, idea stimuli, concepts, printed brochures, and even videotape materials are exposed to the participants to elicit their reactions. The moderator, prompted by individual responses and the group's interactions, formulates hypotheses that rationalize the exhibited behavior patterns and presents them to the panel. What appears to be "leading" the group is, in essence, a feedback to the group of these hypotheses. Group acceptance of the moderator's summary as correct serves as an early indication of the validity of the hypotheses.

The process of making career decisions is long and complicated. It begins in the earliest years of one's life as one is exposed to different professions, and even continues through the time one is employed and occasionally changes careers. During the course of these decision-making years there are numerous influences that must be considered, including family, friends, and school. Moreover, the decision-making process and the nature of these influences may very well differ among different groups of individuals. This study utilized a complex design that took into consideration a wide variety of these influences.

Focus groups were conducted in State College and Pittsburgh, Pennsylvania; Lafayette, Indiana; Austin, Texas; and Los Angeles, California. Seventeen sessions were conducted, including separate groups of junior high school, high school, and college students; parents, teachers, and counselors; college faculty and practicing civil engineers. Five of the groups consisted entirely of African-American or Hispanic-American subjects, while the balance were either Caucasian or ethnically mixed (see Table 6 in Part 1). All groups featured a mix of male and female participants.

Aside from these general characteristics, each group had additional selection criteria. All junior high and high school students were selected on the assumption that they were likely to attend college, and efforts were made to ensure that most of them in any group had not participated in an engineering awareness or enrichment program within the past 2 years. These students and their parents were screened to ensure that they did not have a strong aversion to mathematics and science. The college students were selected to provide a mixture of civil engineering, other engineering, and mathematics and science majors. Members of the study team in each geographic area used their local contacts to identify potential group members, and screened and recruited the group participants following guidelines and procedures specified by the Brand Consulting Group.

All sessions were conducted between September 25 and October 30, 1990. A single moderator conducted all of the sessions; all were viewed by at least one study team principal, and usually other observers from the local host organization or from the NCHRP project panel. Following each session the moderator and observers participated in an intensive post-group critique, both to formulate tentative conclusions and to map out the strategies to be pursued at future sessions. This latter procedure proved to be very helpful. For example, the profound lack of recognition of the civil engineering field that was evident in the earliest sessions suggested a strategy of focusing on the specialty areas within civil engineering and educating participants about the profession, which proved to be highly successful in later sessions. All sessions were recorded on both audio and videotape for future reference.

The focus groups proved to be highly effective means of data collection, in that they produced observations that are very difficult to capture through questionnaires and other quantitative methods. Also, the technique permitted continuous formulation, testing, and refinement of hypotheses about the perceptions and attitudes of the target groups. In fact, toward the end of the study the responses elicited from the subjects were nearly all predictable, which is a form of validation of the findings.

Civil engineering is a complex profession in a complex field, and in no way can only 17 intensive group sessions provide totally definitive results. Considering the variations in locality and societal background among the group participants, many of the various segments studied were investigated only once or twice. Thus, although the information obtained can justifiably be regarded as valid, it cannot be regarded as statistically reliable. A summary of the market research study findings follows.

Attitudes Toward Mathematics and Science

The student participants in the focus groups exhibited no consistent pattern of preferences for mathematics, science, or other subjects. Many students who performed very well in mathematics reported a greater liking for English, history, or social studies. Not unexpectedly, the teacher emerged as the primary variable affecting subject preferences. Enthusiastic and well-qualified mathematics and science teachers provided superior experiences for their students and motivated them to persist in the subject area.

Consistent across all of the groups was the opinion that mathematics classes paid too little attention to practical applications. Teachers were often reported to be unable to explain the relevance of mathematical concepts, to the frustration of the students. All would welcome the use of problems and examples relating concepts to career-oriented situations, as opposed to the artificial and outdated materials that are often still in use. For example, geometry and trigonometry could be related to surveying and layout problems, structural analysis problems could be used in algebra classes, and so on. Teachers report that they would use this type of material if it were prepackaged and integrated into the existing curriculum. Relevance is perceived to be less of a problem in science classes because they tend to emphasize familiar and observable phenomena.

Parents do not report placing any emphasis on mathematics and science; rather, they tend to focus on classes where their child needs assistance. They want their children to do well in all of their classes, and to acquire a well-rounded education that will equip them for a variety of higher education and career possibilities. Many parents do not feel qualified to help their children in mathematics and science, and this tends to be inversely correlated with socioeconomic status (since lower income households are less likely to have a parent engaged in a technical field).

Secondary school guidance counselors did not seem to play much of a role in influencing student attitudes toward mathematics and science, nor in student course selections, for the focus group participants. They are heavily involved in preparing stu-

dents for admission to college, and many do not seem to have sufficient staff or time for career counseling and related course selection advising. In better staffed school districts, counselors *are* available to provide a broader array of services.

Career Planning

Students do not seem to be paying much serious attention to career planning, especially at the earlier grade levels. In elementary school, career interests tend to be stimulated by environmental influences (family, friends, hobbies, television) rather than by what happens at school. Students and parents share the view that junior high school is too early for career planning. In high school, there is increasing recognition that career options must be seriously considered, but students tend to be preoccupied with decisions related to higher education — whether to go to college, and where.

Many students (and parents) have given some thought to desired career attributes. The number one concern of the students appears to be money. Students want to be qualified for a high-paying job, and want to know specific salary amounts for various career fields. Other desired attributes include reasonable work hours, lack of stress, variety in the daily work routine, and potential for advancement. Parents want accurate and reliable information about career attributes and educational requirements to be available for their children. They do *not* want their children exposed to high-powered sales presentations concerning any single career.

There is a wide variance in the number and types of career information opportunities made available to secondary school students. The types of programs offered include career days, required social science classes with career awareness coverage, aptitude and preference testing, and, at the high end of the spectrum, multimedia career information centers. Most of these resources are viewed without a great deal of enthusiasm by the students, but are used by some to good effect. Summer programs and other types of enrichment experiences, many of which are offered to expose target groups to technical careers, are an exception; they are received enthusiastically and are highly successful.

As noted previously, there is little or no exposure to career-related materials in the classroom. Teachers are interested in using such materials, but feel that they cannot be added to an already overcrowded curriculum. The interested teachers also recognize that they have to be trained in the career-related aspects of the subjects that they teach, and possibly in the use of the materials that might be made available. Finding the time for doing all of this takes great motivation and dedication on the part of the teacher.

Students who do well in mathematics and science classes are often actively directed toward careers in engineering. This occurs despite the fact that many teachers and other adults who are doing the directing have little or no accurate knowledge about the field. Thus, it is not uncommon to find first- and second-year engineering students pursuing studies toward a career about which they actually know very little. The typical engineering curriculum exacerbates this problem by keeping the student out of significant engineering coursework until the third year. In this regard, the colleges mimic the high schools; students spend a lot of time studying mathematics and science, and are not exposed to their relevance to engineering. As a consequence, students report feeling isolated and not really a part of the engineering school, which likely contributes to the high attrition rates experienced in the first 2 years. Another result is that many students report having changed their major several times before settling on one that they really like. This seems to be less of a problem at universities that offer a first-year Introduction to Engineering course.

Student comments on perceived problems with the typical engineering curriculum reinforce the observations and conclusions of engineering education leaders. While many students opt out of engineering during the first 2 years because it does not really match their interests and abilities, there are many others who leave prior to learning very much about engineering. Providing early exposure to engineering design and problem solving would help to retain qualified students in the engineering majors. This conclusion is shared by many of the focus group participants, and by today's engineering education leadership.

Attitudes Toward Careers

Students, and virtually everyone else involved in the career choice process, have very little information about specific careers, especially engineering, and know even less about civil engineering. Incongruously, civil engineering images dominate the responses of those who know anything at all about engineering. Engineers are often identified as those who design or build roads and bridges. Aerospace and electronics are also often mentioned. Those who do have some career awareness trace it to contact with role models and other types of direct experiences. For example, the increasing use of computers in the schools has caused many youngsters to embrace careers in the computer field. Relatives, family friends, or neighbors who work in engineering, including part-time or summer employment in engineering or related fields, are often cited as sources of information and motivation.

The term "civil engineering" generates almost no name recognition among the uninformed. Most people have no idea what civil engineers do. Others hold unflattering images of the field, often related to road construction or maintenance, or to working for local government in uninspiring and low-paying jobs. After some exposure to materials describing civil engineering, many of the participants opined that the civil engineer's job was boring and repetitive. The practicing civil engineers, in contrast, reported great variety in their assignments, which was a source of job satisfaction.

Most non-engineers perceive there to be few differences in degree requirements and technical rigor among the various engineering disciplines. Engineering students and educators are more likely than the general populace to believe that civil engineering and industrial engineering are less demanding technically than the other engineering majors. Some practicing civil engineers also share this opinion.

While "civil engineering" conveys no striking images, the various specialty areas within the field generate more recognition. Most people can relate to terms such as transportation engineering, structural engineering, construction, and environmental engineering. Unfortunately, for the ultimate objectives of this study, transportation engineering did not create much interest or excitement among the group participants. The perception is that the field is not challenging because the techniques for building roads and bridges are already well known, and all of the needed facilities are already in place. There is also concern about the number and quality of future career opportunities.

There are similar common misperceptions about the other civil engineering specialties. Structural engineers are thought to be subordinate to architects. Construction engineers are one step removed from job site workers.

Environmental engineering generated considerable excitement. There is widespread recognition that there are important environmental problems to be solved. Women seem to be particularly attracted to this field, perhaps because of its strong relationship with the biological and chemical sciences (as opposed to mechanical sciences, where women still tend to be culturally disadvantaged).

Professional licensing is one thing that tends to confer distinction upon civil engineering as a career choice. This is particularly true among parents.

Practicing civil engineers and college faculty do not believe that there is a current or impending shortage of new entrants to the profession. If there is a shortage, why have not salaries increased to correct it? They also note that technicians and computers now perform many of the tasks that used to be performed by entry-level engineers, which has reduced the need below historical levels of demand. Some parents also believe that civil engineering type work can be done by technicians, who have less than 4 years of post-secondary school study.

Attitudes of Women and Minorities

The attitudes of women and minorities, among all of the groups where they were participants, were very close to those of the other group members. In this context, it is important to remember that most of the participants were from the middle class, and the students were highly likely to attend college (or were already in college). Women, African-Americans, and Hispanic-Americans knew neither more nor less about engineering and civil engineering, nor were they markedly different in their reaction to civil engineering as a potential career choice. Some points of emphasis or differing perceptions of the women and minority participants are highlighted below.

Minority students were more likely to have participated in college awareness or mathematics, science, and engineering enrichment programs than the general population of students. Thus is also true of women students, but to a lesser extent. Most students who had participated in these programs did not retain much specific knowledge, but they were more likely to have some awareness of the various engineering career possibilities. They also reported favorable reactions to these programs.

College-bound minority students recognize that there are several different sources of financial aid available to them, and are highly motivated to do well in their studies in order to qualify for this aid. Most work during the school year, and anticipate a need to continue doing this during their college years.

The remunerative aspects of engineering careers were of relatively greater concern to minority students. When queried about the important factors in selecting a career, receiving a high salary was by far the number one response. The goal seemed to be to become firmly entrenched in the middle class. Goals such as service to society seemed to be of lesser concern. However, this observation is related more to economic status than to ethnicity. Minority parents, in addition to sharing the emphasis on salary levels, were also highly concerned about job availability and stability, and felt that a good job would be one that carried with it authority, social power, or prestige. They were also somewhat troubled by the recruiting efforts being directed toward their children; several cautioned against painting a false picture about the relative desirability of engineering or civil engineering careers.

The need to put students in touch with appropriate role models was mentioned more often and with greater emphasis by minority group members, and to some extent by women. Two separate college groups pointed out that the schools need to draw on the African and Hispanic heritages to show the role of these cultures in the development of engineering works. College students were often mentioned as good role models for communicating with secondary school students.

Minority and women engineering students are aware of the special problems that they face in entering a profession dominated by white males. Most of the group participants were active in the National Society of Black Engineers, the Society of Hispanic Professional Engineers, or the Society of Women Engineers. Many were also active in the student chapter of the principal professional society in their discipline, such as the American Society of Civil Engineers.

There is still a chilly climate for women and minorities who wish to enter engineering. This begins in the classrooms, where some older white male faculty who have little experience in working with these "new" entrants to engineering accord them harsh or prejudicial treatment. Foreign-born faculty and teaching assistants from cultures where women do not become engineers are also reportedly guilty of discriminatory behavior toward women engineering students. Interestingly, male engineering students reportedly accept women students without reservation, while male students in less demanding majors still seem to subscribe to the old biases and stereotypes (i.e., women engineering students are too busy with their studies to have time for dating or other activities and interests).

The chilly climate continues into the workplace. Minorities and women are concerned that others will believe that their jobs and promotions are due to their race or sex, rather than to their qualifications. Women face sexual harassment, especially at construction sites.

The obstacles facing women engineers have generated a defiant attitude in many, particularly those who have been in the field for several years. They feel that they have to shrug off sexist comments and actions, and prove themselves every day on the job. Similar attributes were observed among minority group members. In short, despite the progress that has been made in creating equal opportunity, it still takes extraordinary perseverance and toughness for women and minorities to succeed in engineering, particularly civil engineering.

Many women and minority group members feel that they will have to start their own firms to get around the "glass ceiling" that blocks advancement in large organizations. Civil engineering is noted as a field where entrepreneurship is highly possible, but not many students (minority or others) seem to be aware of this. This aspect of civil engineering can be used as a motivator to attract individuals who wish to leapfrog the barriers noted above.

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president designate of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Frank Press and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

ADDRESS CORRECTION REQUESTED