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ABSTRACT

A model career preparation program for first-year engineering women at Purdue University is described. Key elements of this project, which is funded through the Women's Educational Equity Act, are: a course designed to provide engineering and career information and practical experience; a means of evaluating the methods and results; wide dissemination of all useful information generated by the experimental course; and the collection of information relevant to programs for women in engineering. The program includes lecture-discussions of contemporary problems in the field by role-model lecturers; career-planning and counseling session; and "hands-on" laboratory experiences broadly related to the field of engineering. The first experimental course was evaluated by pre-testing and post-testing with standardized tests and specially-constructed surveys relating to educational goals and self-concepts of students. The pilot course was revised and offered again as a set of three modules to provide more flexibility to meet student needs. Test results for both years (1977 and 1978) are included. Information dissemination about the program has included a slide-tape set about the model program and experimental course; conference papers; professional journal articles; an Associated Press news story; and public service television spots. A brief annotated bibliography focusing on pre-college backgrounds and college and post-college development of women in engineering is presented, and comments from two students are included. (SW)

Putting It All Together: A Model Program for Women Entering Engineering

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Contents

"I decided to study engineering because I like math and it offers many good job opportunities for women."

Abstract

In September 1976, the Purdue University Department of Freshman Engineering initiated the development of a model career preparation program for first-year engineering women. This project, made possible by grants awarded through the Women's Educational Equity Act (WEEA), was completed in August, 1978. The results, including background commentary and final conclusions, are presented herein.

The Purdue project was designed to establish an educational model for women entering engineering which would enable them to participate more fully and more equitably in their education. The basic principles which evolved, however, are applicable to a wide range of disciplines by no means restricted to engineering. In brief, the project consists of key elements: a course designed to provide engineering and career information and practical experience; a means of evaluating the methods and results; the wide dissemination of all useful information generated by the experimental course; and the collection of information relevant to programs for women in engineering.

In essence, the model career preparation program as applied to engineering provides beginning engineering students with (1) lecture-discussions of contemporary problems in the field by role-model lecturers; (2) career-planning and counseling sessions; and (3) "hands-on" laboratory experiences broadly related to the fields of engineering. These concepts were incorporated in a pilot course offered in the Spring of 1977. Though open to all students the course was specifically designed to meet the needs of freshman engineering women.

The first experimental course was evaluated by pre- and post-testing with standardized tests and specially-constructed surveys related to educational goals and self concepts of students. With the aid of these results as well as through direct student and staff observations, the pilot course was revised and offered again as a set of three modules to provide more flexibility to meet student needs the following year. The generally positive data analysis and test results for both years have been completed and are described in this report. Especially noteworthy was the closing of the gap in technical knowledge which existed between men and women by participating in the program.

In a variety of ways, the information generated during the development of this program is being disseminated nationally and internationally to enable others to benefit from its merits as well as to avoid difficulties which have been identified and solved during two years of experience. Representatives from institutions across the nation have participated in a workshop at Purdue on engineering education for women. A slide-tape set describing the model program and experimental course has been prepared and is available on request; and besides the first annual report and this comprehensive final report, the program has been presented in numerous conference papers, described in professional journals, and featured in an Associated Press news story and in public service television spots.

A brief annotated bibliography has been prepared which focuses on pre-college backgrounds plus college and post-college development of women in engineering. The bibliography is specially directed toward problem identification, special programs and potential action-oriented policies including the role of women in management.

Background

Every year there is an increase in the percentage of jobs held by American women. Today nearly half of the women in the United States spend twenty-five to thirty years of their lifetimes in the work force. In the future, the greatest growth in employment for these women will be in professional occupations, and increasingly they are entering non-traditional fields "off-limits" to their grandmothers and mothers. Of these fields, more and more women are pursuing careers in engineering, which in the past has been almost exclusively a white male profession. Of over one million engineers in the United States in 1974, only .7 of 1 percent were women, even though women constituted almost 40% of the employed labor force (NSF, 1977) and over half of the U.S. population.

The situation, however, is rapidly changing according to the Scientific Manpower Commission Report (1975) and the Engineering Manpower Commission Report (1976). The number of women enrolled nationally in engineering programs increased over ninefold from 3061 in 1969 to 28,773 in 1977. At Purdue University, the growth rate was even more dramatic —over a seventeenfold increase (46 to 817 undergraduate women) in the period between 1968 and 1976. By the fall of 1978, the number of women in engineering exceeded 1,000 at Purdue University.

Women have good reasons to be increasingly interested in engineering. Engineering is one of the largest professions in the U.S., employing over a million engineers in 1970 and anticipating an increase to one and one-half million in the 1980's (NSF 1975). The opportunities for women entering the profession are excellent, particularly because of the increasing demand for engineering in energy, environment, transportation and computer fields as well as affirmative action and other equal employment opportunity programs; and salaries for women entering this competitive market are now sometimes higher than for men. Starting salaries approaching $20,000 have recently been reported (Chemical Engineering News, May 8, 1978).

Trends of Freshman Women and Undergraduate Women Enrollments in Engineering

Year	Total Undergraduate U.S.	Total Undergraduate Purdue	Freshman (1st year) U.S.	Freshman (1st year) Purdue
1969	3061	47	1181	24
1970	3569	59	1457	25
1971	3983	78	1541	26
1972	4487	87	1542	27
1973	6064	143	2417	69
1974	9828	244	4216	118
1975	15852	462	6730	233
1976	21936	647	8545	253
1977	28773	817	9921	300

Sources: Engineering Manpower Commission, Engineering & Technology Enrollments—Fall (1969-1976)

Office of the Registrar, Purdue University

But women must overcome a number of difficulties in making such career decisions. Though the underutilization of women in engineering is now reflected in a greatly increased demand for female engineers resulting from the trend toward equalization, studies show that women feel most sure of career-goal success in fields traditionally associated with their sex. Since men have predominated in the field of engineering, it therefore has not been perceived as a field providing extensive opportunities for women.

While women tend to have equal or higher high school grades and verbal abilities than men entering engineering, women typically decide to enter the field much later and are more likely to encounter a variety of problems including both lack of technical know-how and uncertainty in selecting an area of specialization. High school women have often felt they were at a disadvantage in their technical vocabularies because of the differences between their educational and cultural experiences and those of men (Dement, 1962). They are also less likely to have taken mechanical drawing, physics, shop courses or to engage in science related hobbies and pursuits like assembling hi-fi sets or working on the family car, which provide "hands-on" experiences, or reading *Popular Mechanics* or *Aviation Weekly* (Erlick and LeBold, 1977). Finally, high school women most often feel inadequate in several areas of knowledge basic to the study of engineering, including physical science, aeronautics, electronics, and mechanics (Shaycroft, 1967). However, studies conducted by Erlick and LeBold (1977), and LeBold and Richard (1975) reveal that when students had such experiences, they were much more likely to enter scientific-technical fields such as engineering.

Based upon these findings various programs designed for women in non-traditional scientific fields were examined, including the University of Oklahoma's "New Avenues" program for women in physics (Pollack and Little, 1973; Shay, 1975) and Cornell's program for women in engineering (Hall and Hall, 1975) which including a series of basic laboratory experiences; and Purdue's program for women in science (Brown, 1975) which involved the use of role-model lecturers from different areas in science, special counseling and an unstructured research experience. As a result, the Purdue University Department of Freshman Engineering designed, field-tested, and evaluated a model program for freshman women in engineering. The project was funded by a grant from the U.S. Office of Education under the Women's Educational Equity Act (WEEA).

Project Objectives

Purdue's Educational Equity Project is an attempt to provide women who are entering a non-traditional field with experiences and support services designed to meet their specific needs, especially those related to unequal educational opportunities or societal sex role stereotyping. The basic objectives of the project serve as the structure of this report. They are:

- To develop a model program of coursework for first-year women which would enable them to participate more fully and fairly in engineering education.
- To evaluate the effectiveness of the program, including the educational materials, by field testing in an experimental course and comparing the experiences of men and women who participated in the course with similar men and women who did not.
- To disseminate nationally information about the model program, including conference papers, articles, and audio-visual materials which describe and explain the program, and through an invitational workshop focusing on the model program and key areas of concern related to women entering engineering.
- To study factors influencing the education and careers of women in engineering, and to collect, store and synthesize information related to that topic.

The Model Career Preparation Program

The Purdue educational equity model is based upon several elements regarded by the project staff as essential to a successful program involving any career-oriented target group.

In Purdue's model program, the specific target group were women entering the field of engineering, although the experimental course was also open to men and was particularly appropriate for urban, minority and foreign students who often have similar needs.

In attempting to provide an early educational experience for women entering engineering which would give them a more equal opportunity to pursue studies and a career in engineering, the project staff carefully reviewed known educational equity programs, analyzed the relevant women's studies literature identified through bibliographical searches and other sources, and weighed many possible options against experience already gained from past women's engineering programs at Purdue.

Experiences during the freshman year of college are often critical to decisions regarding career choice. The retention of students in engineering programs is closely related to student's interest in beginning courses as well as to grades (DeLaurentis and Molnar, 1973). The stimulation of interest through intervention programs including counseling, research and project experiences (LeBold and Pruett, 1973) and role-model programs (Brown, 1975) can have a significant impact on retention in engineering and other fields, and are essential elements in the Purdue Model Career Preparation Program.

Even further, it was determined (Erlick and LeBold, 1975) that women who plan to enter engineering, physical science or mathematics are at a disadvantage with regard to many technical "hands-on" activities, even though they have an advantage in other more traditionally feminine "hands-on" activities such as handicrafts, clothing design, and typing. It was thus decided that an intervention program which provided technical "hands-on" experiences was also essential for a successful model program.

In a survey conducted at the end of the first semester of 1975-76, over 60% of the 200 beginning Purdue women engineering students indicated they would be interested in a course which would assist them in making an engineering career decision. Of those women interested, 70% preferred a course that stressed interest and achievement testing, 85% preferred a course which would provide career and role models, and 95% preferred a "hands-on" type experience (Le Bold and Humphries, 1976). The organization of the Purdue model program reflects these needs and interests in its basic elements:

- Exposure to career opportunities through lectures on current and relevant topics by a variety of role-model lecturers who are experts in their respective field.

- Career-planning centering upon the process of evaluating one's individual interests and abilities and developing meaningful career objectives and a plan of action.

- Introduction to the field of engineering to acquaint student with what will be studied in preparation for the career.

- "Hands-on" experiences designed to provide direct contact with tools, materials, and equipment associated with engineering and technology. This was provided by the instruction in the operation of and use of hand and power tools, and the completion of selected laboratory construction projects. Special efforts were made to include experiences which women are less likely to have due to lack of opportunities to enroll in industrial arts and shop courses or to pursue technical-mechanical activities.

"Ever since I was small I have always liked math and science. I like to do 'brainteasers' type puzzles and games . . . I took math and science courses all four years of high school, and I guess I always thought that I would do something related to those fields."

In the planning stages of the model program coursework, current topics such as environment and energy were selected for classroom investigation based upon their appeal to women, who were perceived as generally more sensitive and committed than men to societal needs. Material of this nature was also regarded as less likely to overwhelm students with technical jargon which could be confusing or frustrating in the early stages of an engineering education. Such topics are also advantageous for their contemporary and future orientation which links current societal concerns with the excitement of potential breakthroughs yet to come. The organization of topics along traditional lines was rejected as less innovative and already available in existing orientation courses. It was also felt that to systematically cover each field of engineering in such a class would lead to only a superficial view of each which would be less effective than a more in-depth investigation of selected areas. Furthermore, many engineering problems are not simply in the domain of one exclusive field but represent an integrated approach of several fields, such as chemical, mechanical, and electrical engineering. It was this integrated approach that was chosen for the role-model lectures, with the addition of speakers from outside the engineering profession to help demonstrate the truly interdisciplinary character of society's approach to the solution of environmental energy, and other pressing technological problems.

The decision to include a career planning segment in the experimental course was prompted by a number of factors. As a whole, women are less certain of their career choices than men, often because of the strains placed upon career aspirations by traditional attitudes toward marriage, home and family. Women, especially those entering engineering are more likely to have made their decision later in their high school years and are required to make early decisions usually within the first year regarding a field of specialization, e.g., aeronautical, chemical, civil, electrical engineering. Women are also more likely to put higher premiums than men upon interpersonal relationships, and are more likely to be open about their feelings. As a result, the combination of career planning with career counseling of individual students appeared to be particularly suited to the needs of first-year women in engineering. These students frequently need guidance in their career decisions and are amenable to personal discussions of their progress, interests and abilities as a means of facilitating their decision to remain or leave engineering, select a major field and develop a plan to succeed in their studies. It was felt that a specific kind of counseling was also appropriate for this purpose to help reverse the effects of any previous (and more traditional) counseling which may have guided the women away from careers in non-traditional fields. In many cases, women need support to resist the negative feelings or perceptions they have experienced through sex and career role stereotyping among peers, family, teachers, counselors and mass media. Though group planning and counseling techniques were used both in 1977 and 1978, the emphasis upon individual counseling increased as the need and effectiveness of this approach became more apparent.

Special attention was given in the career planning phase of the course to the use and limitations of interest tests in assisting students in making career choices. Such tests are often sex-biased and can lead to misinterpretation for the woman seeking to identify traditional and non-traditional occupations related to her interests. For this reason, the new Strong-Campbell Interest Inventory was selected because of its special efforts to provide normative data on both men and women in a wide variety of fields and occupations. The Purdue Interest Questionnaire is similarly designed to provide non-biased guidance in the selection of engineering fields.

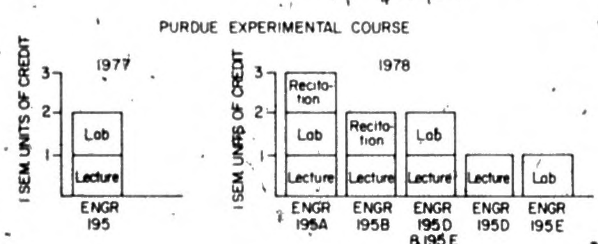
The "hands-on" laboratory segment was a natural choice for inclusion in an educational equity-oriented course. With few exceptions, women students entering college have had little opportunity to work with hand and power tools or perform other machine or engine-related tasks typically regarded as the domain of boys and men. As one Purdue student put it, she had simply been "cook and bake" at home and "home-ec" at school, while her brothers and father repaired the family car, hammered the nails and worked with the power tools. Not until she had participated in the "hands-on" lab did she find that she was actually capable of performing manual tasks she had always regarded as "men's work." The implications of this attitude are highly significant for women entering a field traditionally regarded as a male domain. The psychological disadvantage of feeling unfamiliar with tools and tasks that most male engineering students take for granted can be quite unsettling for a female student who hopes to compete on an equal basis for grades and employment. The "hands-on" lab offers for many female students the first opportunity to catch up with their male counterparts in a very real way. As another female engineering student explained, "I couldn't even get into a shop course in high school, even though I tried three years in a row." Following her "hands-on" lab experience, the same student now routinely uses a variety of power and hand tools in her bio-medical laboratory shop, and has even instructed a new male student who arrived with virtually no tool experience, a task which admittedly gave her a real sense of satisfaction. Though the "hands-on" laboratory exercises were not selected to represent tasks specifically applicable to a given field of engineering, they represent a basic set of skills aimed at bringing the mechanical aptitudes of female students closer to parity with men in general. In practice, many students do find uses for their newly-acquired skills in engineering-related coursework, experimental work, or in cooperative semester work in private industry.

"Pollution cleanup isn't just 'icky,' it's a very fascinating subject. It amazes me how much work goes into successfully purifying water, air and land."

The Experimental Course

The Model Program was field tested twice using an experimental course. As the experimental course developed, its format passed through two phases. When it was offered initially in the Spring semester of 1977, the course was available only as Engineering 195: "Engineering, Skills, and Career Planning." Students attended a one-hour lecture and a two-hour laboratory each week, and earned two semester units of credit.

In the spring of 1978, a structurally-revised version of the experimental course was offered. No longer a single course, Engineering 195 was available in three modules and presented a number of options. As indicated in the graph below, the addition of a new recitation segment made it possible to earn a total of three semester units of credit, while a variety of other combinations for less credit were also allowed.



Role Model Lecture

In both the 1977 experimental course and the modularized course offered in 1978, the role-model lecture sessions were regarded as one of the basic elements in a model career preparation program. Each of the lecture sessions was designed to feature role-model speakers chosen to represent both men and women, minority and majority group members, young and old, single, and married individuals. The speakers were selected to include a variety of engineering careers, and some were drawn from professions outside engineering, such as psychology, economics, and physics. Some of the speakers were members of Purdue's staff, while others were representatives of industry or governmental agencies. In each instance, the speakers presented topics of current concern and interest, such as energy, the environment, transportation, productivity and bio-medicine. One of the main goals of the lectures was to show the relationship between many of the engineering fields in solving problems affecting society, as well as to point out the relationship between engineering and other fields in solving these problems. Students were also familiarized with individual aspects of the profession, such as the elements in a "typical" day of an environmental engineer, including data collection, computer operation and problem solving.

In the experimental course, supplemental reading assignments were taken from an *Energy and Introduction to Engineering* by Glorioso and Hill. One of the major difficulties perceived by the students at this point was that of maintaining the relationship between engineering and the lectures and reading assignments.

ENGINEERING 195 (1977)

Lecture Topics

1. **Career Planning I—Interests, Abilities & Opportunities**
2. **Environment: Industry, and Government Perspectives**
3. **Environment: Waste Disposal and Civil Engineering**
4. **Solar Energy & Electrical Engineering**
5. **Nuclear Energy and Power Plants**
6. **The Economics of Energy**
7. **Private & Public Transportation & Mechanical Engineering**
8. **Career Opportunities in the U.S. Department of Transportation**
9. **Engineering Design & Laboratories**
10. **The Pacemaker & New Bio-Engineering Developments**
11. **Bio-Medicine, Bio-Engineering and Clinical Engineering**
12. **Military Aircraft, International Relations & Productivity**
13. **Productivity & Industrial Engineering**
14. **Career Planning II—Short and Long Range**

"I think the tests can be very useful to any undecided person because they seem to do a good job of matching your interests with various careers."

In the revised 1978 course, the relationship between the lecture material and engineering was more carefully delineated and speakers were requested to include specific areas of context in their remarks. Speakers from such professions as horticulture and history added to the social relevancy of the topics, and computers, a previously overlooked but important area, were included in the subject matter. At the same time, the technical readings for the role-model lectures were expanded and improved, a revision which contributed much in the way of continuity. The addition of Gray and Martin's *Growth and Implications for the Future* was particularly useful in this respect, since it provided introductory material for many of the topics. Several sources, including professional journals, popular magazines, excerpts from engineering textbooks, and a variety of other publications such as the "Energy" reprint from the *Christian Science Monitor* were used for the readings.

In both 1977 and 1978 it proved challenging to locate minority and female role models who had been working sufficiently long enough to discuss relevant aspects of a given content area. Although efforts were made during 1978 to also include a handicapped person, we were unable to locate a qualified speaker available within the time restraints under which the course was organized.

LECTURE TOPICS AND READINGS 1978

Lecture Topics

1. **General Overview of Environment**
2. **Industrial & Government Involvement-Environment**
3. **Historical Background of Energy**
4. **Solar Heating Energy**
5. **Nuclear Energy**
6. **Bio-Medical Engineering**
7. **The "BART" System of Transportation**
8. **Space Shuttle Transportation**
9. **Government Responsibilities in Transportation**
10. **Overview of Productivity**
11. **Computers: Future Uses in Society**
12. **Industrial Applications of Computers**

Career Planning 1977

Invaluable to students who have experienced difficulties in the final selection of a career or an area of specialization, the career-planning segment of the model program was an essential component of both the 1977 and 1978 versions of the experimental course. Three career-planning sessions were scheduled for Engineering 195 in the spring of 1977.

The first session, held at the beginning of the semester, served as a combination lecture and discussion meeting which emphasized the interaction of interests, abilities or aptitudes, individual goals and aspirations. These factors were compared to the students' perceptions of what kinds of things an engineer does. The students were also given career-planning activity packets which enabled them to complete an in-class identification of their interests.

The second career-planning session was held at mid-semester, and consisted of a short lecture about the use and interpretation of two interest inventories the students had completed in the initial class meetings of the course. The first, the *Strong-Campbell Interest Inventory* (Strong & Campbell, 1974), measures an individual's interests rather than ability or aptitude. Special emphasis was given to overall interest patterns using Holland's (1974) typologies (Realistic, Investigative, Artistic, Social, Enterprising, or Conventional). Students and counselors could examine basic interests and many other male and female occupational patterns. They then could combine the results with other personal interest information to assist in the career decision-making process. The second, the *Purdue Interest Questionnaire* (LeBold, et al. 1976), was developed specifically to assist college students in the selection of a major area of study and career in engineering or if transferring from engineering in selecting a non engineering field or major. Following these explanatory remarks, each student was provided with the results in the form of profiles for both interest questionnaires which indicated the range of each student's interest, from low to high, in the areas

"I really never stopped to think of what I wanted my life's goals to be, what my philosophy of life is, what an ideal job is and what my personal traits and qualities are. After all of these things were introduced I really started thinking about them."

specified. After the lectures, the students were divided into small groups for further questionnaire interpretation. If they wished to do so, students were also given the opportunity to discuss their profiles in individual counseling sessions.

In the third session, the students were asked to project themselves into the future and imagine themselves at age 50, and then write a biographical introduction to be given at a banquet at which they were the main speaker. This element of personal expression in the career decision-making process was related to another feature of the course: the keeping of daily class journals throughout the semester. As the students reacted to each lecture or laboratory situation, their recorded thoughts served to provide perspective on general interests and career preferences later in the semester. These journals are the source of the quoted comments which appear throughout this report.

In the revised experimental course format used the following spring, the career-planning sessions were modified and incorporated in the recitation module.

1978

The recitation module was adopted for the second offering of the experimental course to provide further discussion of seminar and laboratory topics and their relation to engineering fields and design. This module was limited to second-semester freshmen who had not decided upon a professional engineering school. The career planning element of the pilot course thus was relevant for every student enrolled in the module. Career planning activities in the 1978 revision of the course were designed to encourage students to concentrate more upon the process of career planning. To this end they were to:

Increase their awareness of their interests and abilities.

Explore career opportunities, particularly in fields of engineering.

Develop a plan of action.

Each student participated in class sessions and individual counseling sessions. Interest inventories were also discussed on an individual basis, which also proved helpful for students seeking to identify interests and judge abilities. Continuing the emphasis upon the importance of monitoring and reviewing individual perceptions, the students were asked to keep a journal of their class reactions as had been done in the previous year. The first entry in their journals, however, was to be an autobiographical sketch, a form of initial "stock-taking" which enabled students and instructors to consider information which was often useful during career counseling sessions.

As in the spring of 1977, the students in the revised course module participated in three career-planning class sessions and completed interest questionnaires in the initial class sessions. During the first session, they were presented with the concept of career planning and asked to describe their aspirations, values, and preferences by responding to items such as:

- Ultimate life goal
- Philosophy of life
- Ideal job specifications
- Starting salary
- Accomplishments envisioned
- Five most important achievements to date
- What kind of people preferred to associate with on daily basis
- What needs to be done to make the world a better place in which to live

The answers to these questions were often surprising to the students themselves, who had never directly considered such personal aspirations and interests. In this way, the students became immediately aware of elements in the process of active career planning which enabled them to experience a sense of progress in the earliest phase of the course.

The second career-planning session was essentially not changed but did include an additional measuring device, the *Self Directed Search* (Holland, 1974). Unlike the *Strong Campbell Interest Inventory* and the *Purdue Interest Questionnaire*, this device leads the student through a self-scoring pattern of interest inventories and self-evaluation to the immediate identification of career possibilities which place high in compatability, and offers yet another form of career guidance.

In the final session, the students were asked to summarize their career planning progress, and a decision-making exercise emphasizing leadership and communication skills was completed both in individual counseling sessions and in groups.

"I had no idea there could be that much to modeling a sophisticated system on the computer. I am beginning to appreciate why some of the engineering schools make such a fuss about programming skills."

Recitation Module

One conclusion shared by the project staff upon evaluation of the first offering of the experimental course was the need to relate the "hands-on" laboratory and role-model lectures even more closely to the field of engineering. To accomplish this a recitation module was devised for the spring of 1978. This module, with classes meeting once each week, was conceived as a means of introducing students more formally to the field of engineering.

In particular, the recitation module provided a sense of continuity between the "hands-on" laboratory and role-model lecture modules by pointing out the relationship of the lectures and labs to each of the fields of engineering and amplifying the importance of individual elements to engineering in general. In introducing the students to the field of engineering, the recitation module stressed two aspects of engineering: report writing and preliminary design.

At the outset of the semester, students were asked to select a topic in the field of engineering of interest to them. Early classes were devoted to readings and class discussions related to the theory and practice of technical writing, including research techniques, speeches, and briefings. Following the guidelines presented in the *Professional Writing Handbook*, the students searched the available literature for materials related to their own topics, handed in a bibliography of sources they had discovered, and by mid-semester completed their reports. Besides discussions of report writing, class time in the period preceding completion of these reports was also given to the discussion of basic topics of interest and concern to those in the engineering profession. In the second half of the semester emphasis was placed upon preliminary design in the area of transportation. This engineering subject was followed from theory through mathematical modeling, parametric cost studies, and discussions of model and prototype testing. Since the recitation module had been limited to second semester freshmen who had completed or were taking computer programming, it was possible to make use of computers during this phase of the class. Selected for this purpose was the BIZJET model computer program designed to determine the effects that changes in parameters of the computer program would have on the projected performance and economy of special aircraft. This linked the practical application of computer technology with a project which developed from beginning to end before the students' eyes.

ENGINEERING 195 (1978)

Recitation Module Topics

1. **Environmental Concerns of the Engineer; The Literature Search**
2. **Career Planning I**
3. **The Research Report**
4. **Energy Concerns of the Engineer; Science, Engineering & Technology**
5. **Engineering Functions**
6. **Career Planning II**
7. **Engineering Aspects of Transportation; The Design Process**
8. **Mathematical Modelling**
9. **Computer Modelling**
10. **Prototype Testing**
11. **Design & Lab Reports**
12. **Career Planning III**

"I learned how to saw a piece of wood and how to use a torque wrench today. My Dad has a Torque wrench and I never knew what it was. I also learned I can't hammer straight. All my nails went crooked."

The "Hands-On" Lab

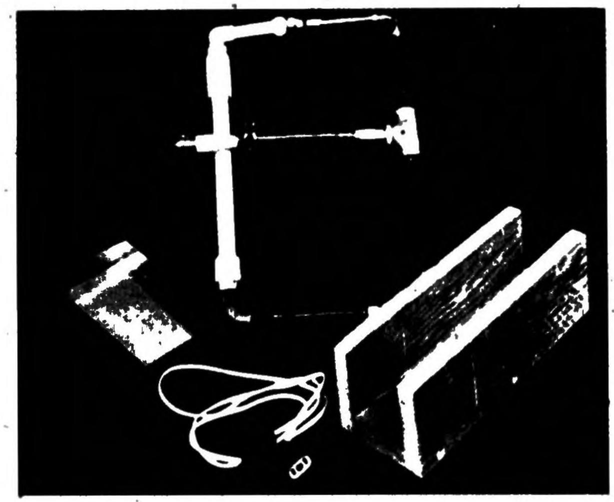
In their pre-college years, most women do not have the same opportunities as men to become proficient with hand tools or electrical and mechanical devices related to the field of engineering. These limitations frequently result in a lack of confidence which can be a significant influence upon women tentatively entering the engineering profession. The retention or loss of such students at this crucial point may thus depend upon the availability of intervention programs which can provide the basic information, "hands-on" experiences, and skills needed both to reinforce the students' confidence in their own abilities and to remove any notion that a great majority of their classmates enjoy an advantage which will always hinder equal competition.

Although, as has been mentioned, some men could also benefit from such "hands-on" technical experience, the need is greater and more prevalent among women; and it is they who benefit most from such experiences. The increasing number of female engineering students, as well as of minority and foreign students, greatly enhances the desirability of a viable "hands-on" practical experience for this important pool of potential engineers.

The 1977 Lab

The "hands-on" laboratory segment of the experimental course first offered in 1977 was adopted to familiarize freshman women engineers with hand tools and mechanical equipment which are frequently important as background information for engineering design, experimental work and production, and to increase their confidence and ability to do and understand technical work by developing skills many did not have. A series of twelve two-hour laboratory sessions concerned with common engineering and technical skills useful in modern-day life was designed to achieve these ends.

Problematic in planning these laboratory sessions was the need to provide experiences which could be adequately covered in the available time period. Ideally, students should feel by the end of the class that they have grasped the essence of a project, observed a demonstration of the tools and techniques associated with the project, and used the tools and materials themselves in the appropriate manner. The experiences appeared to be particularly rewarding when the goal was to produce an expendable article which the student was allowed to keep. The fact that many



of the tools or projects were familiar did not seem so important as the fact that the students were able to do things themselves with tools and materials their brothers or fathers had used almost exclusively. In designing these laboratory sessions, of course, attention was given both to the relevancy of a given experience to the students' future, and to the availability of materials and tools required.

"Today was a blast! We got to change spark plugs, points, and check the timing and other things. I've really learned a lot in this lab and I'm glad I took it."

To reinforce the emphasis upon learning so that students would not be concerned if they had no prior knowledge of skills in a given area, the laboratory grade was based not upon the quality of the work, but upon satisfactory completion of the lab sessions. As can be seen, the labs began with basic hand tools and gained in depth and breadth as the semester progressed. In the first offering of the "hands-on" laboratory, six different texts were used.

The responsibility of teaching the "hands-on" laboratory at Purdue was assumed by the Department of Aviation Technology, which could provide instructors having expertise in the use of engineering tools and familiarity with the correct techniques and safety procedures. Coordination by one department also provided excellent continuity for the students, who used the same facilities and had the same instructors each time.

Each class began with a short discussion of the purpose of the laboratory, after which students were given a Lab Planning Sheet which described what was to be accomplished.

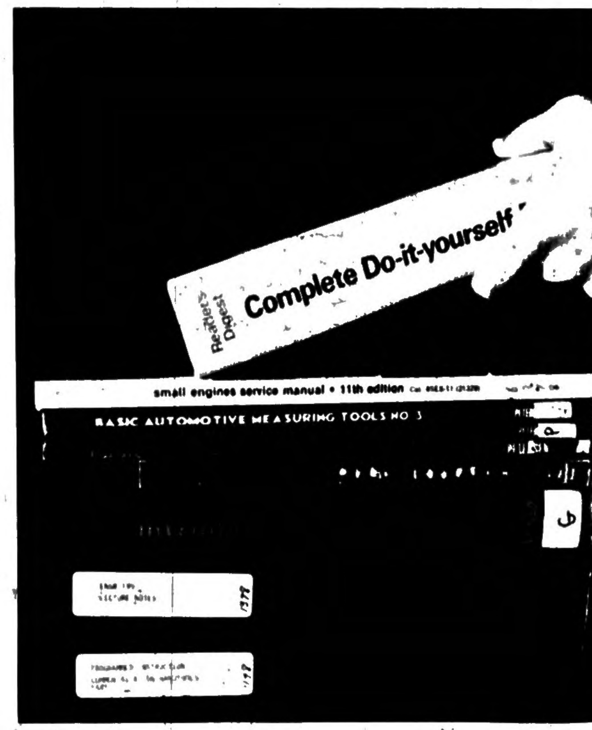
Prior to each laboratory session, the students were also given background readings to amplify various parts of the lab and explain the tools and project at hand. Following a demonstration of tools and techniques, the students proceeded with their assignments. At the completion of the lab, five to ten minutes were spent summarizing the accomplishments of the period.

ENGINEERING 195 (1977)

Week	*Laboratory Topics*
1.	**Hand Tools**
2.	**Power Hand Tools**
3.	**Power Tools**
4.	**Woodwork**
5.	**Electricity**
6.	**Plumbing**
7.	**Introduction to Recip. Engr.**
8.	**Small Engines**
9.	**Intro. to Automotives**
10.	**Auto Safety Inspection**
11.	**Auto Tune-up**
12.	**Turbine Engines**

The 1978 Lab

While the pilot version of the "hands-on" laboratory was well received by the students, several areas of change were deemed appropriate. Besides the fact that the "hands-on" laboratory was made available as an independent module, additional supervision by student assistants diminished student waiting time for answers to questions and provided more individual help. Limited changes were also made in the reading assignments and laboratory projects.



Evaluation

The evaluation of Purdue's WEEA model program was carried out to determine the extent to which the course objectives were attained. Both the 1977 and 1978 offerings of the course attempted to increase the students' knowledge of engineering and societal problems and to impart very basic engineering-related skills. The course was also aimed at improved self-perceptions of capabilities and knowledge regarding these areas, increased participation in engineering related activities, and more clearly defined career goals.

Testing, Design, and Registration Procedures for Both Years

With these objectives in mind, measurement instruments were either developed or previously developed instruments were used, and an experimental design was implemented as a basis for evaluating the course achievement of objectives.

For the 1977 field test of the model, technical knowledge was evaluated through the use of seven standardized tests including:

(1) *The Purdue Mechanical Adaptability Test* (Lawshe and Tiffin, 1946)
(2) *The Bennett Mechanical Comprehension Test* (Bennett, 1968).
(3) *The Tool Knowledge Test* (ETS, 1962).
(4) *The Mechanical Information Test* (ETS, 1962).
(5) *The Electrical Information Test* (ETS, 1962).
(6) *The Auto Mechanics Test* (Campbell and Johnson, 1969).
(7) *The Mechanics Test* (Flannigan, 1960).

A survey, *The 1977 Purdue Engineering Career Planning Study*, was constructed to measure self-perceptions of capabilities, participation in engineering related activities, importance and achievement of goals related to engineering education, and attitudes toward women in engineering. Technical capability items for the survey were taken from the *Job Analysis Questionnaire* (McCormick, 1968) and the *Job Activity Preference Questionnaire* (Mecham et al, 1962) and were modified to determine perceived capabilities. The attitudes toward Women in Engineering portion of the survey was taken from the *Women as Managers Scales* (Peters, Terborg, Taynor, Ilgen, 1974) and utilized as an engineering scale. In addition to the modification of the *Job Activity Preference Questionnaire* for the survey to measure perceived capabilities the JAPQ was also used directly to measure changes in activity preferences by the experimental and control groups. A second survey was used to evaluate the various aspects of the course.

The 1977 study was a quasi-experimental design and included the use of two control groups, as well as two experimental groups. One control group consisted of students enrolled in a freshman engineering design class and the other group consisted of students who had expressed an interest in the experimental course, but were unable to enroll. The two experimental groups included the same seminar but the laboratories differed in that one was primarily women (4 men and 23 women) and the other about equally divided between (11) men and (15) women. The technical knowledge and comprehension tests and the *1977 Purdue Engineering Career Planning Study* preliminary and final surveys were given to students in all groups during the first and final week of classes. The course evaluation survey was given to only the course participants upon completion of the 1977 course offering.

The 1978 course offering, a revised and modularized version of the 1977 course, incorporated measurement instruments that were previously used, revised, or newly-constructed and revised or constructed others in some cases. The Tool Knowledge Test, Mechanical Information Test and Electrical Information Test were used again to evaluate the laboratory module. In addition, a special laboratory exam, the *1978 Engineering 195 Laboratory Examination*, was created to be directly related to the knowledge to be learned in the laboratory and the laboratory objectives. An exam was also constructed for the seminar module, the *1978 Freshman Engineering Seminar Examination.* This exam was used to determine the knowledge gained as a result of participating in the seminar. The *1977 Purdue Engineering Career Planning Study* was revised to reflect the changes in the 1978 course and renamed the preliminary and final *1978 Purdue Introduction to Engineering Survey.* The 1978 survey omitted the attitudes toward women in engineering scales and these questions were replaced with questions concerning the measurement of the extent of career development. *The Personal Attributes Questionnaire* (Spence, Helmreich, and Stapp, 1974) which measures self reports of masculine, feminine, and masculine-feminine (androgynous) characteristics was also administered to students in the course. Again, a second survey was constructed intended for student evaluation of various aspects of the course.

The experimental design of the 1978 course differed considerably from the 1977 design. Although testing was completed during the first and final week of courses as in the 1977 course offering, no comparison groups of persons not participating in the course were used. Instead, for the cognitive tests, direct pre-post-test comparisons were made for those who participated in the various modules. For the *1978 Purdue Introduction to Engineering Survey,* however, persons who participated in the course but did not participate in the particular module of concern for a particular survey scale were used as a quasi-control group for those scales. Again the course evaluation survey for the pilot course was given to students to complete at the end of the semester.

"This course helped me feel more comfortable in engineering. It has provided me with an excellent background."

Since the course was primarily planned around the special needs of women, every attempt was made both in 1977 and 1978 to analyze and summarize the data to show how women performed on the testing as compared with men. The two laboratory sessions with differing proportions of men to women in the 1977 study, were used to determine if there would be any differences in testing between the women in the two groups. Because there were no apparent differences, this approach was not utilized again for 1978.

Since there was not room for all interested persons to sign up for the course in both 1977 and 1978, a procedure was implemented each year for determining who would be given priority. The procedure in 1977 differed from the procedure in 1978. For the 1977 course offering it was predetermined that 3/4 of the course be women. 2000 freshman engineering students were given information about the course during the fall semester of 1977. Of these, about 300 expressed an interest in the course. This group was separated according to sex and assigned to the experimental group so that 1/4 were men and 3/4 were women.

For the 1978 course offering a different procedure was used. Those who were interested in the course completed a short form in which they gave their anticipated major, estimation of knowledge about engineering and societal problems, and estimation of knowledge about technical activities. They were also asked to indicate which modules they were interested in. From this, each person was given composite scores and those who were considered to have the greatest need for each module were given top priority regardless of sex. After the priority group for each module had signed up, all other interested persons were given an opportunity to sign up for the course on a first-come-first-served basis.

Cognitive Testing Analysis and Results

The results for the 1977 cognitive testing were analyzed in several ways including several analyses of variance and covariances and between and within group one-tailed t-tests. Generally the results revealed statistically significant improvement of experimental groups on the most relevant post tests and statistically significant improvement of experimental groups over control groups on the most relevant tests. Table 1 presents the results for all groups on all tests in the 1977 cognitive testing. The results are given in raw score as well as standard T* score form based on the total group pre-test mean and standard deviation. Within group t-test significance levels indicate the extent of improvement for the experimental and control groups in the study. Figure 1 shows the extent of improvement of the experimental women over the control men on the pre- and post-testing. Women in the experimental group gained considerably in technical knowledge, compared to control men as a result of the 15 week course, although the gap in knowledge wasn't completely closed.

*T scores convert raw scores to a common base with 50 as the mean and 10 the standard deviation.

TABLE 1

Standard and Raw Score Means and T-test Significance Levels for Differences Between Correlated Pre- and Post-Cognitive Test Means for Each Group in the Purdue 1977 WEEA Engineering Skills and Career Planning Study.

	GROUPS														
COGNITIVE	EXPER WOMEN		CONTROL WOMEN		EXPER MEN		CONTROL MEN		TOTAL EXPER		TOTAL CONTROL				
TEST*	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	SD	POST
PMA															
SS**	44	49	43	47	55	61	53	55	47	52	52	54	50	10	53
RS***	22	27^{3}	21	24	34	39^{3}	32	34^{1}	25	31^{3}	30	32^{2}	28	11	31
BMC															
SS**	43	47	45	49	58	59	53	54	48	50	52	53	50	10	52
RS***	48	51^{3}	49	52	59	59	55	55	51	53^{3}	54	55^{1}	53	7	54
TKT															
SS**	42	46	40	44	60	62	55	56	47	50	52	54	50	10	52
RS***	16	18^{3}	15	17^{1}	25	26^{1}	22	23	18	[illegible]^{3}	21	22^{1}	20	5	21
MIT															
SS**	44	51	42	44	55	61	54	56	47	54	52	54	50	10	54
RS***	15	19^{3}	14	14	21	24^{3}	21	22^{1}	17	20^{3}	19	20^{1}	18	6	20
EIT															
SS**	44	50	42	45	54	58	55	56	47	52	52	54	50	10	53
RS	16	19^{3}	15	17	21	23^{2}	21	22^{1}	17	20^{3}	20	21^{2}	19	5	21
AMT															
SS**	45	48	44	49	52	59	53	56	47	51	51	54	50	10	53
RS***	4	4	3	4^{2}	5	7^{1}	6	6^{1}	4	5^{1}	5	6^{1}	5	3	5
SUM															
SS**	44	49	43	46	56	60	54	55	47	52	52	54	50	10	53
RS****	120	137^{3}	116	128^{2}	163	178^{3}	156	161^{3}	132	148^{3}	149	155^{3}	142	35	152
No. Cases	(37)	(37)	(14)	(14)	(14)	(14)	(61)	(61)	(51)	(51)	(75)	(75)	(126)	(126)	

*Cognitive test titles:	# Items	Pre-test K-R20 Reliab.
PMA - Purdue Mechanical Adaptability Test	60	.91
BMC - Bennett Mechanical Comprehension Test	68	.93
TKT - Tool Knowledge Test	30	.80
MIT - Mechanical Information Test	30	.90
EIT - Electrical Information Test	30	.93
AMT - Auto Mechanics Test	20	.93
SUM - Total of all (Due to rounding error totals may not be equal)	188	.94

**Standard Scores
***Raw Scores
Significance levels based on 1 tailed t-tests:

$^{1}p < .05$
$^{2}p < .01$
$^{3}p < .001$

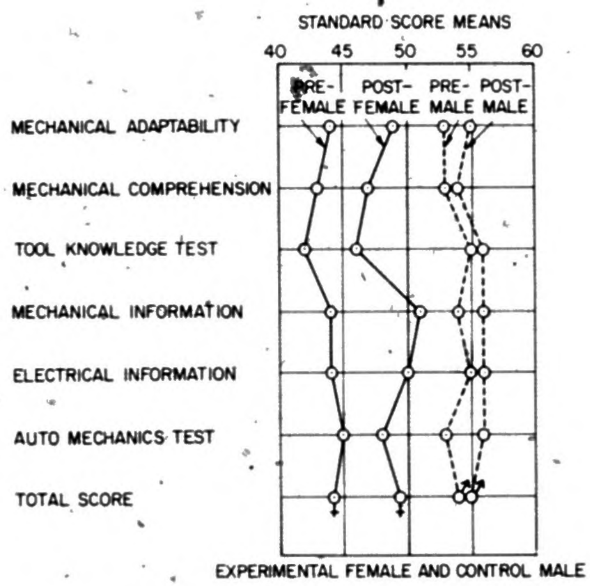


FIG. 1

The results of the 1978 cognitive testing were analyzed by between and within group one-tailed t-tests. Statistically significant improvement of women over men in the study were found on most of the tests on the between group t-tests. On the within group t-tests highly statistically significant differences were found for both men and women between the pre- and post-tests for all tests. The raw and standard scores for within group t-tests are presented in Table 2 along with the significance levels. Figures 2A—2E present pre-post-test results for the men and women in the 1978 study.

Table 2 and Figure 2A indicates that at the beginning of the course, the male students participating in the seminar module were significantly better informed regarding energy, environment, transportation, bio-

TABLE 2

Standard and Raw Score Means and T-Test Significance Levels for Differences Between Correlated Pre- and Post-Cognitive Test Means for Each Group in the Purdue 1978 WEEA Engineering Skills and Career Planning Study.

	WOMEN		MEN		COMBINED PRE		
COGNITIVE TEST*	PRE	POST	PRE	POST	PRE	SD	POST
SEM							
Standard Scores	45	59[3]	53	62[3]	50	10	61[3]
Raw Scores	18.6	24.0	21.5	25.3	20.5	4.0	24.9
(No. Cases)	(30)	(30)	(56)	(56)	(86)		(86)
LAB							
Standard Scores	46	57[3]	57	62[3]	50	10	59[3]
Raw Scores	45.6	64.7	64.1	73.1	52.6	17.0	67.9
(No. Cases)	(38)	(38)	(23)	(23)	(61)		(61)
TKT							
Standard Scores	46	55[3]	56	62[2]	50	10	57[3]
Raw Scores	16.1	19.8	20.5	23.0	17.7	4.7	21.0
(No. Cases)	(38)	(38)	(23)	(23)	(61)		(61)
MIT							
Standard Scores	47	55[3]	56	61[3]	50	10	57[3]
Raw Scores	14.7	19.2	19.9	22.7	16.6	5.6	20.5
(No. Cases)							
EIT							
Standard Scores	46	52[3]	56	59[1]	50	10	54[3]
Raw Scores	15.0	17.8	20.0	21.2	16.9	5.5	19.1
(No. Cases)	(38)	(38)	(23)	(23)	(61)		(61)
TOT							
Standard Scores	46	54[3]	56	62[3]	50	10	57[3]
Raw Scores	45.7	56.8	59.9	66.9	51.1	13.6	60.6
(No. Cases)	(38)	(39)	(23)	(23)	(61)		(61)

*Cognitive Test Title	# of Items	Pre Test K-R20
SEM-Seminar or lecture exam	50	.45
LAB-Laboratory exam	102	.94
TKT-Tool Knowledge Test	30	.90
MIT-Mechanical Information Test	30	.90
EIT-Electrical Information Test	30	.90
TOT-Sum of the TKT, MIT, & EIT	90	.90

Significance levels based on 1-tailed t-tests:

[1] $p < .05$

[2] $p < .01$

[3] $p < .001$

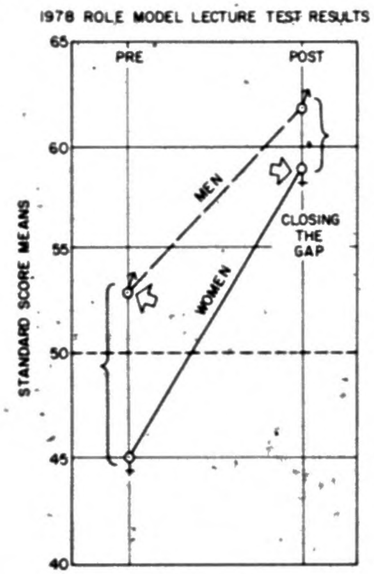


FIG. 2A

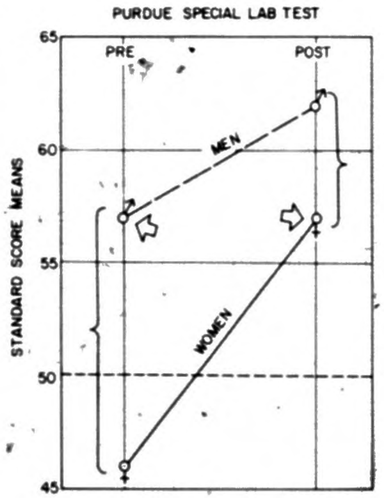


FIG. 2B

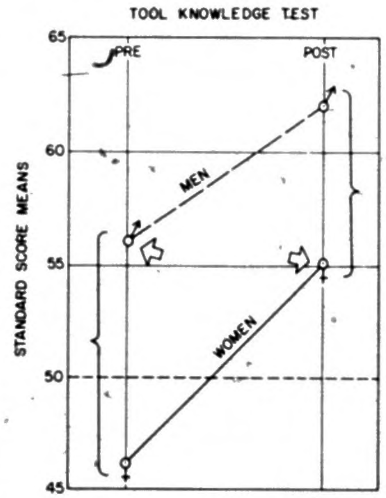


FIG. 2C

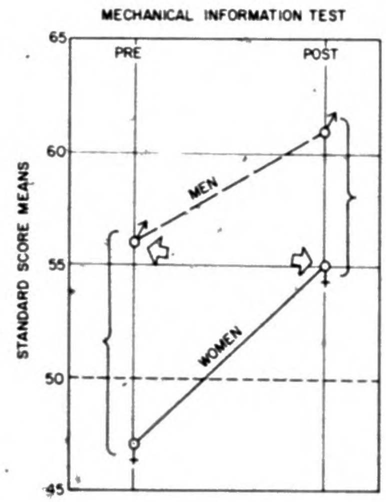


FIG. 2D

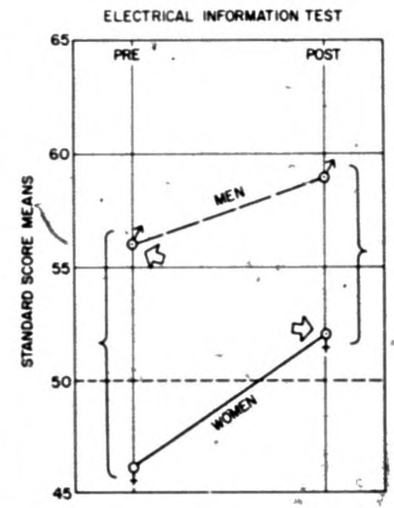


FIG. 2E

medicine, productivity and computers than the women, but by the end of the course, the women had virtually closed the gap. To a lesser degree this was also true with regard to the laboratory module. Table 2 and Figures 2B, 2C, 2D and 2E indicate that male students had significantly higher scores on both the pre- and post-tests, however the women had significantly narrowed the gap, having final scores at almost as high as the men had initially. This was especially true for the special laboratory examination (Figure 2B) and the Mechanical Information Test (Figure 2D).

If comparisons are made on the testing results between the groups who participated in the 1977 and 1978 study, it is seen that for those tests given both years, including the *Tool Knowledge Test, Mechanical Information Test*, and *Electrical Information Test*, neither group differs significantly initially, but there were significant gains for those participating in the experimental program by the end of the course. Therefore the assumption can be made that the laboratory portion of the course was equally successful, at least in terms of knowledge gained in both years.

The 1978 course provided the evaluators with further knowledge about the effectiveness of both the laboratory and seminar, since a special, directly relevant exam was constructed for each.

The results indicated that the laboratory and seminar portion of the course have been successful in increasing the knowledge of participating students in the content areas established as course objectives.

"I would highly recommend the seminar to students who are undecided upon which field to choose."

Affective Survey Analysis and Results Educational Objectives

Of prime interest in the affective areas were the importance, expected achievement, and perceived achievement of the objectives of the seminar, career planning and laboratory phases of the model program by the students. There were no significant differences in the importance that the control and experimental men and women gave to the seminar, career planning and laboratory goals. However, there were highly significant differences between the experimental and control men and women in the expected and perceived achievement of the seminar, and laboratory objectives, but the differences were not highly significant for the career planning objectives. Table 3 provides information regarding perceived achievement of the 1977 experimental and control groups. Highly significant differences were found between the four 1977 groups on perceived achievement of all the seminar goals and on the most relevant laboratory goals.

Comparable data were collected for the 1978 modular course offerings, with similar results. The importance given the seminar, career planning and laboratory goals at the beginning and end of the course were similar. Likewise those taking the seminar module or the seminar and laboratory modules expected and perceived achievement of the seminar goals to a significantly greater extent than those taking only the laboratory module. However, the reverse was true for those taking the laboratory modules compared to those taking the seminar only module. Figures 3A and 3B provide information regarding perceived achievement of the women who participated in the seminar, laboratory, and seminar-laboratory modules. The results with regard to the career planning objectives were similar to those observed in 1977, with no statistically significant differences in the expected or perceived achievements of those participating in the various modules including the recitation module, where some emphasis was given to career planning.

TABLE 3

Percentages of 1977 Females and Males in Experimental and Control Groups Who Felt Each Goal Was Achieved "Very Much" or "To Some" Degree.

RANK ORDER	SEMINAR GOALS:	EXPERIMENTAL FEMALE POST	EXPERIMENTAL MALE POST	CONTROL FEMALE POST	CONTROL MALE POST
1	3. To develop an awareness of the problems of energy and their relationship to fields of engineering.	89%	87%	23%	50%[3]
2	1. To develop an awareness of environmental problems and their relationship to fields of engineering.	83%	87%	23%	36%[3]
3	1.a* To develop an awareness of the problems of transportation and how they relate to engineering fields.	82%	87%	18%	27%[3]
4	5. To develop an awareness of bio-medical problems and their relationship to engineering.	81%	87%	12%	13%[3]
5	7. To develop an awareness of the problems of productivity and its relationship to engineering.	69%	87%	23%	67%[3]
	CAREER PLANNING GOALS:				
1	1.b. To become familiar with areas of study available in engineering.	97%	100%	77%	75%[1]
2	1.d. To become aware of career opportunities in engineering.	94%	93%	88%	71%[1]
3	9. To develop an interest in a specialized field of engineering.	75%	67%	53%	61%
4	11. To develop career plans.	75%	93%	76%	54%[1]
5	13. To develop an identity and sense of self-confidence in regard to career choice and college major.	75%	80%	71%	61%
6	1.c. To become more familiar with areas of study outside of engineering.	70%	67%	53%	39%[1]
7	1.e. To become more aware of career opportunities outside of engineering.	58%	60%	35%	29%[1]
	LABORATORY GOALS:				
1	17. To become familiar with the names and uses of hand tools.	89%	80%	6%	25%[3]
2	29. To develop an understanding for the need for safety in all laboratory areas.	86%	60%	59%	42%[3]
3	19. To develop basic engineering skills.	83%	73%	71%	73%
4	27. To become familiar with automobile engine tune-up procedures.	81%	47%	6%	8%[3]
5	25. To develop a knowledge of the proper functioning of the automobile.	81%	80%	18%	15%[3]

TABLE 3 (Continued)

RANK ORDER	SEMINAR GOALS:	EXPERIMENTAL FEMALE POST	EXPERIMENTAL MALE POST	CONTROL FEMALE POST	CONTROL MALE POST
6	33. To become better able to work in groups.	80%	60%	59%	63%
7	23. To develop an understanding of the basics of the internal combustion engine.	72%	80%	6%	19%[3]
8	31. To become more proficient at independent work.	72%	67%	59%	67%
9	15. Development of critical thinking skills for engineering and science.	69%	67%	65%	79%
10	21. To become familiar with various types of engineering materials.	58%	60%	29%	46%

Based on Chi Square analysis of frequencies:

[1] $p < .05$

[2] $p < .01$

[3] $p < .001$

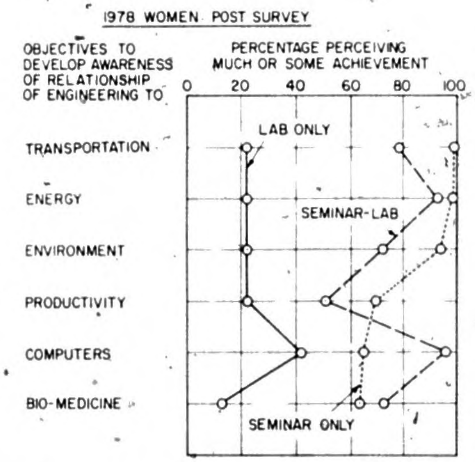


FIG. 3A

TABLE 4

Response Percentages on Selected Items for Women in the 1977 and 1978 Purdue WEEA Study.

	1977 WOMEN EXPERIM PRE	1977 WOMEN EXPERIM POST	1977 WOMEN CONTROL PRE	1977 WOMEN CONTROL POST	1978 WOMEN LAB. ONLY PRE	1978 WOMEN LAB. ONLY POST	1978 WOMEN SEMINAR ONLY PRE	1978 WOMEN SEMINAR ONLY POST	1978 WOMEN LAB & SEMINAR PRE	1978 WOMEN LAB & SEMINAR POST
Women who felt they had considerable capability to perform each activity.										
37. Using measuring devices	43%	69%	56%	41%	56%	83%	75%	63%	50%	79%
38. Observing things you are working with	54%	72%	50%	41%	78%	78%	81%	69%	57%	79%
56. Analyzing information	43%	72%	56%	47%	28%	33%	44%	44%	36%	36%
58. Using hands directly to change things	26%	47%	50%	35%	28%	56%	44%	63%	21%	43%
Women who felt they had considerable capability to use various equipment.										
71. Measuring devices	54%	83%	81%	53%	78%	94%	75%	75%	57%	86%
73. Activation controls	54%	75%	69%	59%	78%	61%	63%	56%	71%	64%

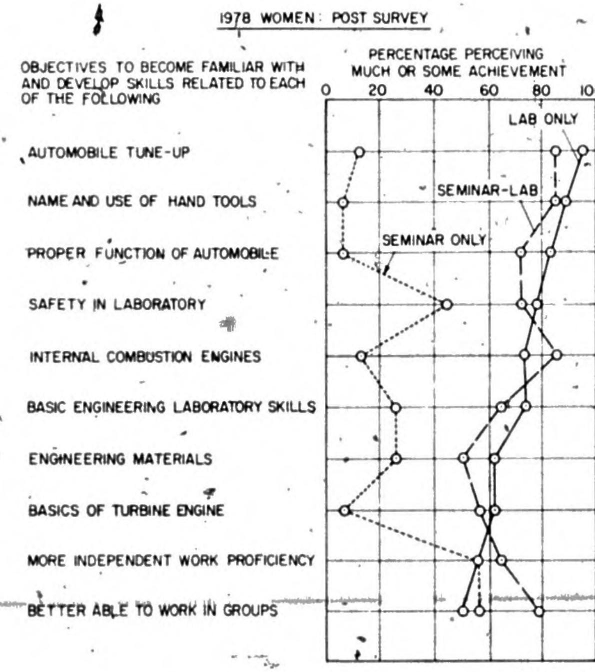


FIG. 3B

"This course has given me a much greater insight into the engineering world. I particularly enjoyed the lectures. As a student trying to become an engineer, it has really helped to know what an engineer actually is."

TABLE 4 (Continued)

	1977 WOMEN				1978 WOMEN					
	EXPERIM		CONTROL		LAB. ONLY		SEMINAR ONLY		LAB & SEMINAR	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
Women who had performed activity within past year.										
88. Made some piece of technical, scientific, or engineering apparatus.	17%	49%	25%	23%	39%	39%	19%	44%	36%	50%
Women who had performed the activity during the past semester.										
108. Plumbing	0%	94%	12%	0%	0%	94%	6%	19%	0%	93%
110. Auto Tune-Up	6%	91%	6%	0%	0%	94%	6%	31%	0%	93%
Talked about the following:										
112. Environment	27%	91%	69%	87%	89%	89%	88%	94%	79%	100%
Read about the following:										
116. Productivity	37%	83%	19%	12%	56%	61%	56%	100%	14%	100%
119. Transportation	40%	89%	54%	87%	83%	78%	69%	100%	57%	100%
Become a part in a project involving following:										
125. Bio-medical	3%	17%	0%	0%	6%	11%	13%	13%	7%	14%

Table 4 gives a selective sampling of some of the items that were included in the survey both years and the response percentages of each group in the 1977 and 1978 studies.

The *1977 Purdue Engineering Career Planning Study* (preliminary form) was factor analyzed, the 150 items resulting in 20 Likert type scales including importance and achievement of course objectives, preference for and participation in engineering-technical activities, perceived technical capabilities, personal-social development and attitudes toward women in engineering. Several analyses were done on both the items and the scales. Several different group chi-square analyses were done on the survey items, and the scales were analyzed by analysis of variance and co-variance and between and within group t-tests for several groups. Significant gains on the scale t-tests for the experimental groups in the 1977 study were primarily in the areas of perceived capabilities, participating in engineering-technical activities, and personal and social development. There were little or no gains in the scales dealing with importance and achievement of objectives, preference for engineering related activities, and attitudes toward women in engineering.

These results indicate that, although students in the 1977 study did not indicate much gain in importance or achievement of objectives, preference for engineering related activities or attitudes, the major effective changes of the experimental group occurred in perception of increased technical capabilities and actual participation in engineering and technical type activities.

The *1978 Purdue Introduction to Engineering Survey* was split into a total of 19 scales, based on the factor analysis from the previous year. Again these scales pertained to importance and achievement of objectives, preference for participation in engineering, engineering-related, and technical activities, and perceived technical capabilities. The attitudes toward women in engineering scales were dropped, however, and replaced by scales dealing with the extensiveness of career planning. Again analyses of both scales and items were done. The items were analyzed separately using the chi-square statistic. The scales were analyzed by two-tailed between and within group t-tests. Although no control groups were used for the 1978 study, the experimental group was split into four groups on some of the analyses: seminar only, laboratory only, seminar and laboratory, and recitation. Each group was again split into two groups: men and women. By using this procedure, those in one module were used as a comparison group for the other modules on the scales relevant for that module.

The 1978 results indicate statistically significant gains of the relevant groups in participation of engineering, engineering-related, and technical activities. Little or no gains occurred in perceived technical capabilities, as they had the previous year, or in any of the other survey scales. These results indicate no affective change between the pre- and post-survey in the areas measured with the exception of the participation in activities related to the course.

Although improvements in the scale scores between the pre- and post-survey were not as great during the 1978 study as they were for the 1977 study, a comparison of those who participated in the four groups in the 1978 study show many group differences in post survey scale scores. Those students who participated in the recitation obtained slightly higher scores on the career scales, while those in the laboratory module were much higher on the laboratory scales. Those participating in the seminar felt they had achieved a knowledge of engineering and societal problems to a greater extent than those that participated only in the lab module.

Figures 4A to 4D show the results of the post-survey scales for the various comparison groups for both 1977 and 1978. The figures show that, essentially, post-survey results are much the same for the participating groups both years. The discrepancy resulting in the significance of the change scores between the two years resulted from higher initial responses of the 1978 groups.

Only minor changes were observed on the JAPQ when it was used in the 1977 study. Previously significant sex differences disappeared on the post test on a few scales relevant to the course, including the scales measuring a preference for controlling machines and processes, using hands and arms to move or position things, and using fingers versus general body movement.

Similar results were observed during the second year on the Personal Attributes Questionnaire, with no significant changes in the self reports of characteristics commonly attributed to males and females. However, women participating in the experimental course became significantly more androgynous as measured by the masculine-feminine scale. For example, self estimates of mechanical ability and aggressiveness increased especially for women participating in the laboratory modules.

FIG. 4A

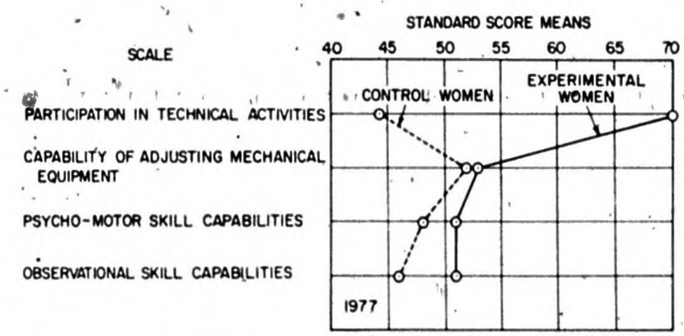


FIG. 4B

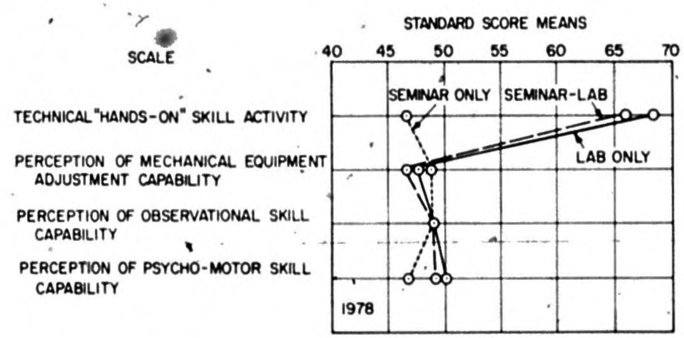


FIG. 4C

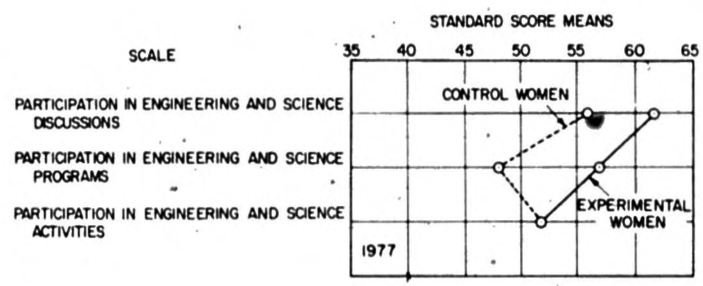
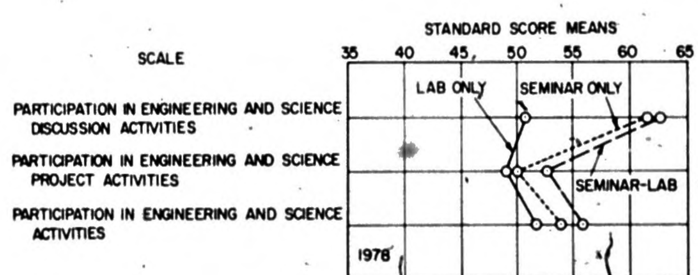


FIG. 4D



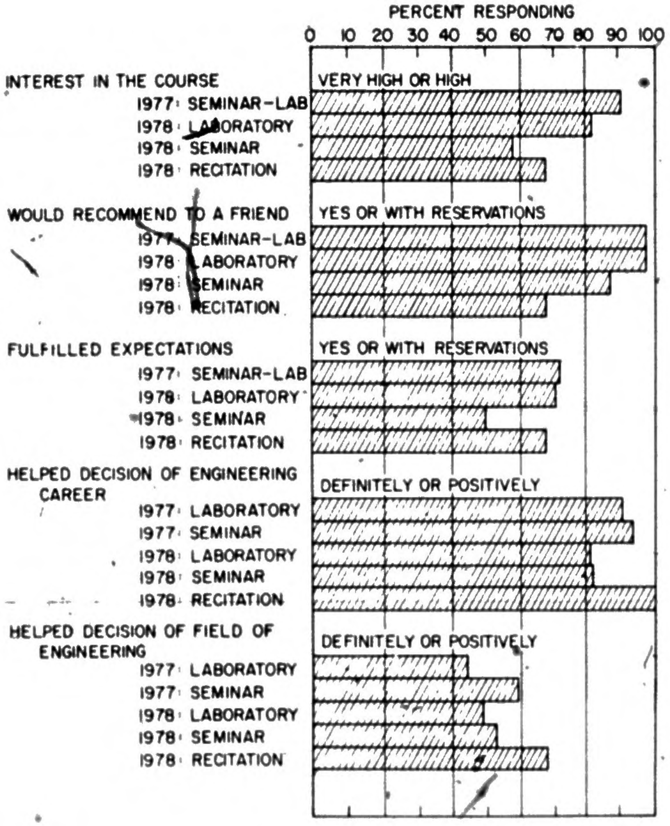


FIG. 5A

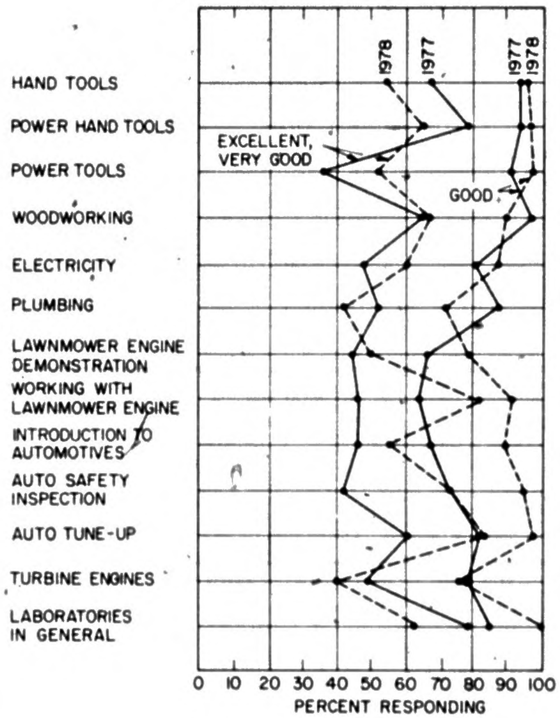


FIG. 5B

The Course Evaluation by Students

The final surveys provided the evaluators with information as to the students perception of the success and evaluation of the course for both years. Figures 5A and 5B present the results of these surveys for both 1977 and 1978. These results show that the students from both years evaluated the course in much the same way and in both cases fairly high.

Evaluation Summary

To summarize, the evaluation results from both 1977 and 1978 indicate that students made comparable and significant cognitive gains both years, and that in both years the course was evaluated very positively by the students.

The 1977 Follow-up Study

A follow-up study of the 1977 group was undertaken to compare retention, transfer, and withdrawal rates of those students who participated in the Engineering 195 course with those who served as the control group. An additional goal was determining the most common reasons for the students' decisions to remain, transfer, or withdraw. The follow-up study was undertaken during the spring of 1978, at which time most of the students were in their fourth semester. Subsequently, those who did not respond to the first follow-up questionnaires mailed in the spring were again mailed questionnaires during the summer. Students who had remained in engineering were mailed a questionnaire to determine their reasons for continuing. Those who transferred or withdrew were sent similar questionnaires to determine their reasons for transferring or withdrawing.

In addition, those students who participated in the Engineering 195 course were asked to complete a short evaluation form to get an idea of the value of various aspects of the course a year later.

Results of the Follow-up Study

Utilizing the data obtained from the registrar, a complete count of everyone in the study who remained, transferred and withdrew as of the 4th semester was taken. The results showed a total retention rate of those in the study to be 69%. 14% had transferred to another school at Purdue before or during the 4th semester, and 17% withdrew from the University. The highest retention rate of 78% was obtained by the women in the 1977 experimental group. This was compared to 62% of the control women, 64% of the experimental men, and 69% of the control men.

Of those who completed the transfer questionnaire, the most common reasons for transferring out of engineering were (1) engineering was too theoretical, (2) they did not feel suited for engineering, (3) they lacked interest in engineering, (4) friends were supportive, and (5) physics courses.

Of those who withdrew from the university the most common reasons were (1) chemistry courses, (2) they were not motivated to study engineering, (3) low morale, (4) they did not feel suited for engineering, and (5) another college had the program they were interested in.

The follow-up evaluation form asked students to indicate the value of each aspect of the experimental course to them. The evaluation revealed that 77% of the students thought the overall course was very valuable, making it the most highly rated aspect of the course in terms of value. The second most highly rated aspect was the laboratories in general, with 73% responding very valuable, and the third most valuable aspect was the lectures in general with 70%; 80% of the students said they were highly interested in the course. 80% said they would recommend the course to others. 90% said they would recommend the laboratory to others.

Figures 6A through 6B show retention, transfer, and withdrawal rates for the groups of students as of the fourth semester.

A complete count of women in the 1977 study during the 5th semester revealed a slight decrease in retention compared to the 4th semester. 74% of the experimental women and 62% of the control women remained in engineering at this time, while 11% and 17% of the groups transferred and 14% and 21% withdrew respectively.

The questionnaire returns for the follow-up study were not as high as had been expected, with an approximate return of only 50% of everyone in the study.

The questionnaire completed during the 4th semester or in the summer by those remaining in engineering revealed the most common reasons for remaining in engineering. Among the women in the study, the five most common reasons for remaining in engineering were: (1) job opportunities, (2) interest in engineering, (3) challenge, (4) interest in courses, and (5) motivation.

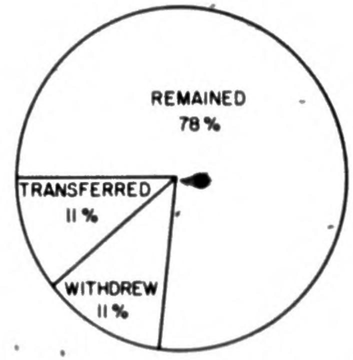


FIG. 6A 1977 Experimental Women

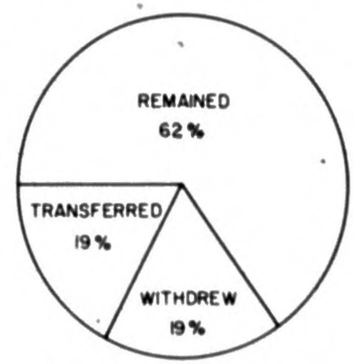


FIG. 6B 1977 Control Women

Dissemination

Purdue's educational equity project has had wide and varied exposure to other institutions and the general public. In an attempt to share its findings with staff members of the profession who may benefit from them, the project staff has presented the following papers during the project period:

Butler, B. R., et al. "Engineering Hands-On Skills." 1977 American Society for Engineering Education Annual Conference, University of North Dakota, June 1977.

Smith, C. D. and LeBold, W. K. "Providing Equity for Freshman Women Entering Engineering via Role-Model Lecture Discussion, Hands-On Laboratory and Career Planning." American Society for Engineering Education Annual Conference, University of North Dakota, June 1977.

Butler, B. R., et al. "An Action Research Proposal to Provide Educational Equity Opportunities for Women in Engineering." 1977 Frontiers in Education Conference, Champaign, Illinois, October 23, 1977.

LeBold, W. K., et al. "An Action Research Model to Provide Equity for Women Entering Engineering." Third Annual Meeting on Women in Education, University of Wisconsin, October 15, 1977.

Heckert, B. L., et al. "A Model Research Program to Provide Equity for Freshman Women Entering Engineering." 1978 American Educational Research Association Annual Meeting, Toronto, Canada, April 1978.

LeBold, W. K., et al. "A Model Program to Provide Educational Equity for Women Beginning in Engineering, International Society for Engineering Education 7th International Symposium, Klagenfurt, Austria, June 1978.

LeBold, W. K. "Ingenieria, Adiestramiento Y Planificacion De La Carrera: Un Programa Modelo." Audio-visual presentation at the First International Congress of Educational Research in Higher Technical Education, Durango, Mexico, August, 1978.

Butler, B. R. and LeBold, W. K. "A Model Course to Introduce Freshmen to Engineering." *Engineering Education*, Spring, 1979.

In addition to these papers, the first annual report on the Purdue WEEA project was distributed extensively locally, regionally and throughout the United States to better share our experiences.

Workshop

A particularly useful feature of the educational equity project as it was originally conceived was a Purdue-hosted invitational conference which would focus upon the results of the first year of the project grant period and facilitate the exchange of information between representatives of educational institutions across the country. Held on December 1-2, 1977, this conference presented a first-hand view of the "hands-on" laboratory experience, the role-model lecture, and special career counseling methods. Since all participants were to take an active part in the conference, the breadth of the workshop was further enhanced by speakers from other institutions who described their own programs designed for women in engineering and technology. In effect the workshop thus became a forum for discussion of current issues and national efforts to increase the number of women in engineering.

To maximize the effectiveness of the conference, a planning survey was developed and mailed to thirty key individuals known for their active roles in women in engineering programs. The program was then planned according to the responses. Personal letters of invitation were mailed to representatives from all known institutions with engineering programs relevant to the workshop, as well as to individuals active in related WEEA or NSF projects concerned with women in engineering and science.

The conferees were key people involved in women's and minority programs around the country. Nearly two-thirds of the forty participants were women, and almost all worked for an engineering college or university. The majority had teaching and counseling experiences, but only a small minority, primarily the male conferees, had considerable "hands-on" power tool, electrical or mechanical experiences.

Following the initial speakers on the morning program a report on Purdue's model career preparation program was presented by the project staff members. This included a slide briefing of the elements of the experimental course and handouts of representative "hands-on" laboratory readings which later would be utilized by the conferees in actual mini "hands-on" lab experiences. Both the career-planning phase and the pre- and post-tests and survey results were also described, and a student assistant gave her own personal evaluation of the course to the conference participants. The luncheon period was also designed to give the conferees an opportunity to talk informally with Purdue Engineering students who had been enrolled in the experimental course.

The afternoon sessions continued to probe into topics related to women in engineering, and were designed to promote the interaction of conference participants. The sessions ended with a trip to the "hands-on" laboratory facility, where each conferee completed a model course laboratory project—the construction of an aluminum box, which entailed the measuring, cutting, bending, and riveting of metal and the use of both hand and power tools.

The experience proved to be as successful and enjoyable for the participants as it had been for the students, and was an excellent demonstration of impact and potential of such course work.

Sessions previously identified as of high interest and concern to the participants filled the morning of the second day, ending with discussion of "The Double Bind"—minority women in engineering.

The conferees' highly positive reaction to the workshop, voiced at the closing luncheon meeting, is reflected as well in the post-conference evaluation survey, which asked conferees to judge the attainment of workshop objectives. Both the objectives and the response of the participants (given in terms of percentage of conferees who felt the objectives were "definitely achieved", "very important", and had "considerably extended" their knowledge) are of note.

Audiovisual and Media

Throughout the project, videotapes and slides have been made of the activities of the students and project staff. Public service videotapes produced from this footage have been provided to and utilized by a number of Indiana television stations, and a narrated slide/tape presentation describing Purdue's career preparation model program has been shown at professional conferences and is available on request to any interested groups. In addition, the Associated Press released a feature story focusing on one of the student participants in the course, a straight-"A" student planning to major in Chemical Engineering. Other materials, such as videotaped interviews with student participants, will also be forthcoming.

Information on Women in Engineering Studies and Programs

A number of ERIC (Educational Resource Information Centers) and other bibliographical searches have been made of unpublished and published literature related to women in engineering and other non-traditional fields. The psychological literature related to sex differences in aptitude, achievement, cognitive development, interests and attitudes has also been searched. A selected list of titles with brief comments on content is provided here as a source aid for those who seek further related information on the subject. (Titles in categories, alphabetized)

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Women in Management

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"The 'Classic' of all assertiveness literature. Discusses definitions and strategies of assertive, non-assertive and aggressive behavior.'"

Baer, J. *How To Be An Assertive (Not Aggressive) Woman In Life, In Love, and On The Job.* The New American Library, Inc., New York, 1976.
"Based on interviews, personal observations and experience, this book introduces the reader to assertiveness training. Provides techniques and guidelines for analyzing personal assertiveness, developing new patterns and being assertive in life."

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Study designed to determine the specific barriers to the promotion of women into managerial positions.

Bird, C. & Mandelbaum, H. *Everything a Woman Needs to Know to Get Paid What She's Worth.* McKay 1973.
This book presents comprehensive material related to affirmative action programs, job outlooks in different fields, and creating jobs within the company.

Bloom, L. A., Coburn, K. & Pearlman, J. *The New Assertive Woman.* New York: Delacorte Press, 1975.
More than a description of a new kind of female behavior, it is a how-to manual aimed at curing passivity and powerlessness in interpersonal relations. Practical assertive training techniques to help women alter self-defeating behavior.

Bolles, R. N. What Color is Your Parachute: A Practical Manual for Job-Hunters and Career Changers. Ten Speed Press, 1975.
This book is designed to give the most practical step-by-step help imaginable to the would-be job-hunter or career-changer.

Bower, S. A. & Bower, G. H. *Asserting Yourself: A Practical Guide for Positive Change.* Addison-Wesley, 1976.
A complete step-by-step program for becoming more assertive. Presents assertiveness training methods to help changing behavior in a positive way, to aid in relating to others more effectively, to help readers stand up for their rights and negotiate productively with others who put them down.

Burrow, M. G. *Women: A World Wide View of Their Management Development Needs.* AMACOM, 1976.
A report on a study being conducted by the author to assert the training and development needs of women managers.

Campbell, D. P. *If You Don't Know Where You're Going, You'll Probably End Up Somewhere Else.* Argus Communications, 1974, Niles, Illinois.
A book on how to create opportunities, then make the most of them.

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A detailed step-by-step explanation of how to decide on a career, where and how to find a job, and the secret of getting hired.

Duerr, C. "Are You Cut Out to be a Manager?" *Management Kinetics.* McGraw-Hill, 1971.
Lessons learned from salvaging businesses for over twenty-five years—management is communication.

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Galassi, M. D. & Gallassi, J. P. *Assert Yourself! How to Be Your Own Person.* Human Sciences Press, New York, 1977.
This book serves a three fold purpose: (1) a self-help manual for the individual who wants to learn to become more assertive on his or her own; (2) a manual for mental health professionals and educators who are developing individual and group assertion training programs, and (3) a manual for members of an assertion training group or class.

Gordon, F. E. & Storber, M. H. *Bringing Women Into Management.* New York, McGraw-Hill, 1975.
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The authors tackle the issue of women in a "man's world" without attacking either sex. Based on interviews with men and women in management. Their analysis discusses the different beliefs and assumptions men and women hold about management careers. The results present a strong case that men and women must change before the male corporate world can become a people's place to work."

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Joneward, D. & Scott, D. *Women as Winners.* Addison-Wesley Publishing Co., 1976.
Transactional analysis for personal growth.

Kanter, Rosabeth M. *Men and Women of the Corporation.* Basic Books, Inc., New York, 1977.
This book is an ethnography of a corporation. Based on the theory that says as long as organizations remain the same, merely replacing men with women will not alone make a difference, it offers descriptive material about life in the large corporate bureaucracy (taken from formal interviews and informal conversation with a single company's personnel) and derives concepts for guiding practical change strategies within the corporate structure.

Koontz, H. & Fulmer, R. M. *Practical Introduction to Business,* Irwin, 1975.
College level text written as an introduction to business that presents how business operates in actual practice.

Lange, A. J. & Jakubowski, P. *Responsible Assertive Behavior.* Champaign, Illinois: Research Press, 1976.
This book gives a comprehensive explanation of assertion training and its techniques, relates assertion to humanistic goals and values, and provides self-help information for incorporating assertiveness into the human personality.

Lynch, E. M. *The Executive Suite—Feminine Style.* New York, ANACOM, 1973.
An inside look at women's roles in management based on personal talks, questionnaires, and informal interviews with ninety-five women in management as a research sample.

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This book focuses on the many factors involved in recruiting, employing, training and advancing women into management, and explains how and why various practices are out of date. Includes guidelines for fresh direction.

Maccoby, M. *The Gamesman: New Corporate Leaders.* Simon and Schuster, 1976.
Based on a study of 250 managers from 12 major companies in different parts of the country, this book discusses how their emotional attitudes influenced their work and how the work itself molded their outlook and motives.

Place, Irene & Armstrong, Alice. *Management Careers for Women,* Louisville, Kentucky, Vocational Guidance Manuals, Inc., 1975.
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Rogalin, W. C. & Pell, A. R. *Women's Guide to Management Positions.* Simon & Schuster, 1975.
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Sheehy, G. *Passages* (Predictable Crises in Adult Life), Dutton, 1974.
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Women in Engineering

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"Purposes of this document are: (1) to measure participation of women, veterans . . . . . (2) to provide a descriptive and comparative analysis . . . . . (3) to highlight selected co-operative education and other special programs that are uniquely responsive . . . . ."

Bugliarello, George, Ed. & Others. Women in Engineering. Bridging the Gap Between Society and Technology. Illinois University, Chicago, 12 July 1971.
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Burton, G. M. "The Power of the Raised Eyebrow." School Counselor, 25, 2, 116-22, November 1977.
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"This report summarizes a conference of thirty minority women in science, engineering, medicine, and dentistry that was held in December 1975, with the support of the National Science Foundation."

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"I loved the course . . . especially the hands-on laboratory. I looked forward each week to going to the class."

Student Comments

Deborah Goetz—Bio-Medical Engineer

My father is a sales engineer at Essex Machinery and Terminals, Fort Wayne, Indiana. In high school, I wasn't certain about my career plans. I leaned toward pre-law, but I was also interested in getting a job before going to graduate or law school. My brother-in-law suggested I consider engineering. I liked math, science and problem-solving. So during my senior year in high school I attended a one-day Women Engineering Seminar at Purdue. Information regarding the expanding career opportunities for women in engineering and meeting a number of women engineers and engineering students, made me enthusiastic about engineering. I was selected by Purdue for a President's Engineering Merit Award and participated in the Freshman Engineering Honors Program.

I enrolled in Purdue's Experimental course, Engineering 195, Engineering Skills and Career Planning. "I loved the course . . . especially the hands-on laboratory. I looked forward each week to going to the class."

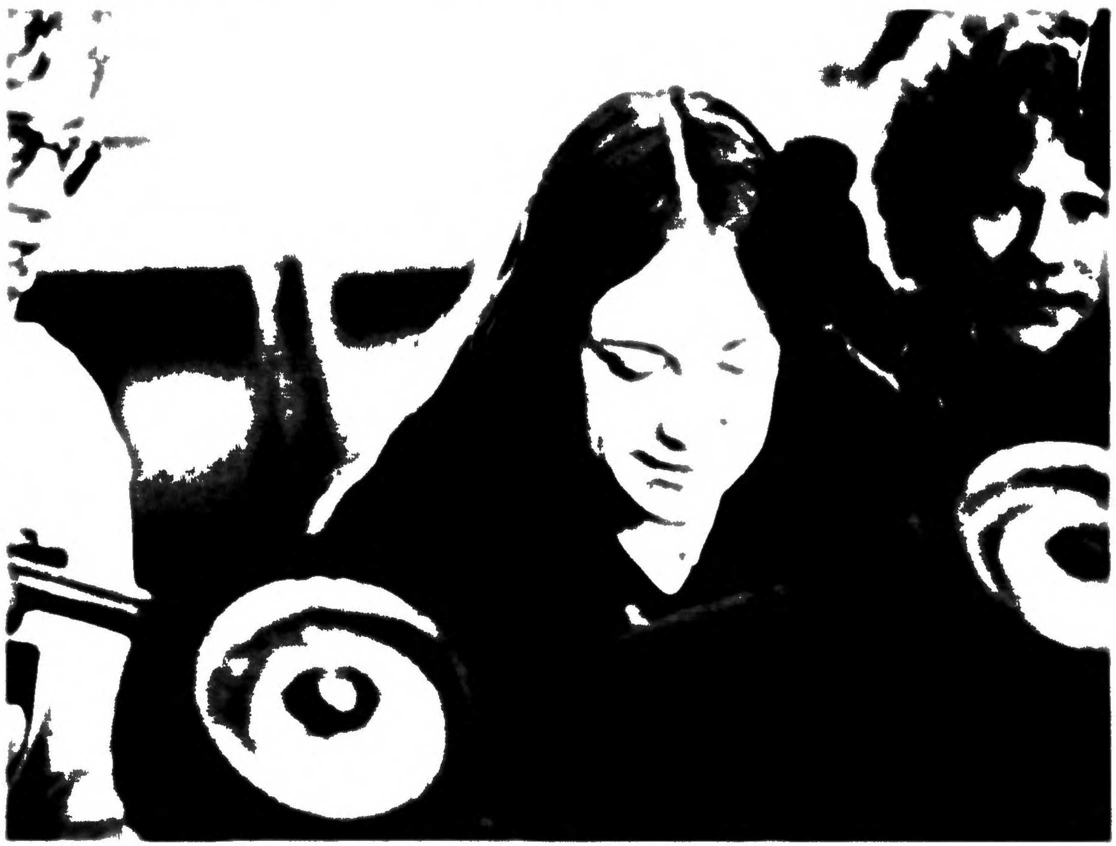
"One of the primary doubts I had about engineering was selecting a field. The seminar lectures on engineering and problems of national concern including environment, transportation and bio-medicine gave me insight not so much on the fields of engineering, but the types of problems engineers face. When the Director of Purdue's Bio-Engineering Center talked about clinical engineering and bio-engineering research I now could see a pathway and an engineering career field for me. He also gave me an opportunity to do research in the bio-engineering labs that summer and I have been working there ever since."

"The hands-on laboratories were great. I especially liked the power tools lab. Recently I helped a bio-engineering graduate student build experimental equipment. He felt a little funny about having a girl teach him how to use power tools. The Engineering 195 laboratory gave me confidence that I could use drills and power saws effectively."

"One of my favorite labs was on the lawnmower and automobile engines. My fiance and I work on cars and engines together. As students, we can only afford used cars and it helps expenses if we can keep them running ourselves."

"The career planning session helped me develop my short and long range goals. The Purdue Interest Questionnaire told me electrical engineering, a field I had never thought of, might be good for me. In my research and courses, I have tried to combine electrical engineering with bio-engineering. Although I would like to work a few years and get some experience, before going to graduate school, when I do go, it will probably be in electrical engineering or bio-engineering."

"A lot of my girl friends would love to have a class like the experimental course. I have encouraged many of them, and guys too, to take the course not only because it's fun, but you learn a lot too!!"



"Women who enter engineering have generally had less experience with things like shop, radio and TV repair . . ."

Purdue Offers Women Technical Knowhow

WEST LAFAYETTE, Ind. (AP) — Until recently, the closest Ann Cole had come to looking under the hood of a car was peering over her dad's shoulder while he made mechanical adjustments.

Today, the 19-year-old chemical engineering freshman at Purdue University is learning to do her own mechanical work in an experimental laboratory course that offers "hands-on" experience for women engineering students.

"Women who enter engineering have generally had less experience with things like shop, radio and TV repair, and auto mechanics, and because of that they're at a disadvantage — they have less confidence in their technical and mechanical abilities than men," says Bill LeBold, professor of engineering and director of engineering education research studies, who directs the program.

Purdue, with the largest undergraduate enrollment of women in engineering in the country, recently received a federal grant for the experimental program.

With two brothers, and a father who owns a General Motors truck dealership, Ann seldom had to lift a finger when it came to mechanics back home in Vincennes.

"Whenever I had any trouble with my car, I'd call Dad, and he'd come, or he'd send over one of the mechanics from the shop," she said. "It never occurred to me to change the oil in my car, either — one of my brothers did it for me."

In the two-credit-hour class, she is learning more than just what to look for under the hood. "It's a very practical course," she explains. "We're learning rewiring, how to make extension cords, how to change fuses, solder and even what to look for when the lawnmower doesn't work."

During the course work, the class completely took apart a lawnmower and put it back together again. Volunteering a repair tip, Ann says, "The problem is usually a spark-plug."

Class members will also be learning how to change tires, oil and transmission fluid, as well as how to clean points and plugs.

Says Earl Hoover, associate professor of aviation technology and lab instructor, "I get the feeling they really enjoy what they're doing — they show a high level of interest."

"I really like the labs," Ann says. "They're a big change from lecture classes, where you can only absorb so much. You get to work with your hands, and try something new each time."

Most of the women in class, Ann notes, agree with her, and one student candidly wrote in her class journal, "This is about the first lab I've ever looked forward to — so I know it must be good."

"Everyone wants to try all the tools," Ann points out. "We don't get graded on labs, so it's relaxing because we're not worrying about making mistakes. In fact, I don't usually remember the names of the tools, but I do remember what they're used for."

So far, according to Ann, only one female classmate is "way ahead of the rest of us — she was planning on becoming a mechanic until her mother persuaded her to go into engineering."

credit: Associated Press

MAKING AN ADJUSTMENT—Engineering student Ann Cole checks an automobile's transmission fluid level in an experimental laboratory course at Purdue University. Designed with the female engineering students in mind, the course teaches them "what most of the guys already know"—from changing fuses to repairing lawnmowers.

Conclusions

In retrospect, many projects once completed assume a sense of concreteness which hinders further revision and improvement. Seldom, however, can an experimental undertaking depending upon unpredictable human response be planned flawlessly the first time. After the first year of development of the model program and experimentation with course work, it became clear that while many elements had been well-chosen, it was not possible to be content with all structural and contentual facets of the model program.

Early in the experimental course offered in 1977, however, it was evident from the students' journal entries and class responses that the role model lectures were a success. The students expressed genuine enthusiasm for the role-model lecturer who provided valuable information about engineering and careers in the field, demonstrated the relationship of engineering to society, and offered personal contact with professional engineers with whom female engineering students could identify.

The basic planning decision to organize the lectures around problem solving topics of current interest to society which would demonstrate the role of the engineer working with members of other professions also proved well founded. This lecture pattern proved highly successful, and was deemed more desirable than an organization of topics by strict division into engineering fields and straightforward consideration of basic engineering functions, such as research and design. Instead, both the role of engineers and engineering, as well as the basic methods associated with the field evolved from the role-model lecturers' discussion of a situation of interest to the class. While the lecturers did not always cover all points of a given topic as envisioned by the project staff, the very presence of female and minority role-models made a statement that often exceeded the speaker's eloquence.

Still, as a result of the experiences of the first year, it was apparent that the success of the lectures could be still further enhanced by providing more detailed information to speakers beforehand which would enable them to structure their remarks to emphasize the relationship of engineering to the topic of the day. It was also decided to provide lecturers with copies of the students' reading material in an effort to further increase the relevancy of the speaker's presentation. A need to wrap up and connect all lectures in a final summation was also noted.

Finally, it was felt that better and more extensive reading materials would be a definite improvement for the next offering of the course, judged both by student reaction to the current materials and the adequacy of the information as perceived by the instructors. In addition, the absence of lectures on the use of computers was determined to be a shortcoming which would be remedied in the next experimental course.

The career planning sessions in the 1977 course were also judged to be useful. Each of the three classes devoted to this topic was organized as a general lecture followed by student participation. Particularly notable was the experience gained from the second class in which results of the Strong-Campbell interest inventory and the Purdue Interest Questionnaire were discussed and then examined by students under the direction of several members of the project staff. This much more individual attention to the interpretation of each student's interest profile was rated highly in the student journals and on subsequent surveys. As a result, provision for even more individual career counseling contact was planned for the next experimental course.

Overall, the career planning segment of the 1977 course achieved its purpose. Positive student reaction to the career guidance provided by the many facets of the planning sessions was pronounced and reflected the great degree to which the course had responded to genuine and strongly-felt needs among the female engineering students. The project staff was also pleased with the results of the first offering, but felt that more emphasis upon explanation of engineering and fields of engineering would be appropriate in the revised course.

The hands-on lab, as it was first offered in 1977, was immediately successful in gaining and holding the interest and enthusiasm of the students who were eager to learn technical manual skills. For most women, the laboratory experience provided not only their first actual contact with such tools, but considerably diminished initial fears about basic deficiencies which may have affected their ability to compete with their male counterparts. The sense of familiarity with tools gained from the course was thus seen by the women as an invaluable accomplishment, and was perceived as greatly reassuring for those who had misapprehensions about entering a "man's field." In addition to the students' responses to this facet of the course, the project staff felt that the work completed by the students could be quite useful to them in the future in providing access to experimental work and to production aspects of engineering.

In terms of improvements for the revised course, it was clear from both student survey results and in-class observation that laboratory sessions with too much demonstration were less effective than those which primarily involved student participation. Plans were thus made to avoid excessive demonstration periods and increase student "hands-on" work as much as practical.

Also apparent was the excitement and satisfaction generated by lab projects which students took with them when completed. Extension cords, mitre boxes, and aluminum trays were tangible results which students delighted in showing to friends and family, and were an appropriate benefit from a course devoted to learning physical skills.

An unexpected difficulty that was a factor throughout the semester was the location of the laboratory itself. Any college or university envisioning such a course must carefully consider the facilities most suitable and best equipped for such activities. Typical classroom facilities which occupy the prime locations on most campuses are not likely to be desirable as laboratory facilities with the requisite equipment and space, but a good rule of thumb is the more centrally located the better. Missing the opening demonstration which is the key to an entire lab can be an extremely frustrating experience for students whose ability to cope with their career decision alone may already be an unsettling factor. It is also helpful for any course of this nature to be placed in the hands of a department which can put its own staff in charge of the organization and operation of the classes. This insures a much more smoothly run experience for the students and places the responsibility for equipment and other materials in the hands of those who are most familiar with the needs associated with the laboratory projects you select.

The evaluation phase of the project also proved to be an important and integral part of the course. Although initially there was considerable apprehension associated with the initial pre-testing of technical "hands-on" knowledge, the significant gains made by the students became self-evident in the final post-testing during the first year and was even more apparent the second year when more relevant and comprehensive testing materials were developed and utilized. The significant cognitive gains made by the women who participated in the "hands-on" laboratory during the first year compared to women and men in the control groups were especially significant. The second year's cognitive testing also provided solid evidence that the model program could significantly close the gaps in knowledge that exist between men and women not only in the "hands-on" technical areas, but also in the areas related to the seminar including energy and environment.

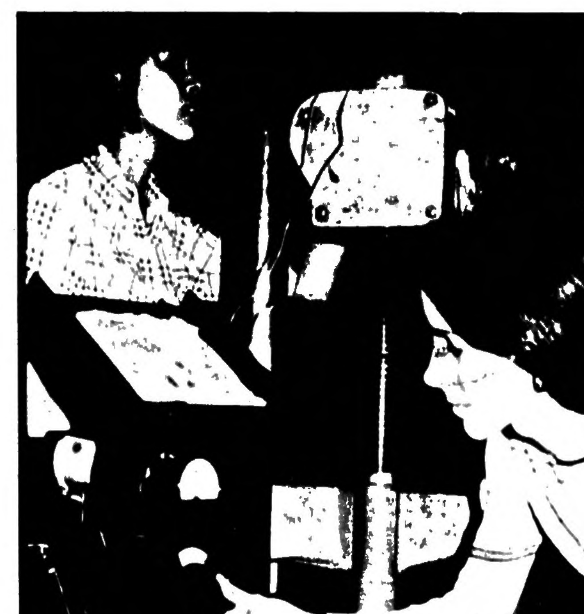
The affective evaluation did not provide as clear cut results. There was ample evidence that the women and men that participated in the lecture-seminars and "hands-on" laboratories expected and perceived the achievement of relevant objectives when compared to women and men who did not have similar experiences. However, in the career planning area those who participated in the career planning phases of the model program were not alone in expecting and perceiving the achievement of a wide range of career related objectives, including those who did not participate in the special career planning phase of the project. Perhaps this was understandable since almost all of those involved in the study were second semester engineering freshmen when key decisions regarding the selection of engineering or non-engineering specialization are almost mandated, plus the fact that only three sessions both years were dedicated specifically to career planning and those sessions were evaluated quite positively.

The results with regard to self concepts of technical capability were mixed. During the first year, significant gains were observed among the women who participated in the model program, but the results were not replicated the second year. Whether or not the larger number of men who participated the second year was a factor is unclear, however a careful exploration of the item data suggests that the items and scales were only tangentially related to the seminar and laboratory and hence the failure to demonstrate significant changes may be due more to the limitations and lack of relevance to the items. Certainly the journal comments for most of the female students tended to reflect strong feelings of confidence and frequently amazement of what was accomplished.

In addition, there is ample evidence that those who did participate in the model program were involved in a wide range of diverse, technical activities including reading and discussing societal problems related to engineering including energy, environment and transportation as well as experiencing "hands-on" activities including the use of hand and power tools, and working on small engines and automobiles—experiences that most other beginning engineering students do not have during their freshman year, and for most of the young women these were activities that they had never experienced previously.

Although our one year follow-up study did indicate slightly higher retention rates both in engineering and at the university, it is unlikely that the model program impact will be significant in this area, at least in the short run. The primary reasons why both men and women leave engineering are the academic demands of mathematics, chemistry, physics, computer programming and engineering graphics or the lack of interest in a program that is highly technical.

In summary, the Purdue Women Educational Equity Project to develop a model program for women beginning their engineering studies resulted in a highly successful program consisting of (1) role model lectures on engineering related societal problems, (2) career planning, and (3) "hands-on" laboratories. The comprehensive evaluation plan demonstrated highly significant gains in cognitive growth, which resulted in a closing of the gap between women and men in their technical and "hands-on" skills. The pre- and post-surveys also indicated that the students participating in the program felt that the course objectives were important and were achieved to a considerable degree. The dissemination phase of the project also indicated a high interest and potential for extending the model program to other institutions and disciplines. The special workshop for women in engineering also identified additional areas for future concern including the role of women in engineering management and the double bind which minority women in engineering face. The high interest in the model program is also evident in the large number of papers and publications which have already been given and published including presentations at six national and two international meetings.



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