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ABSTRACT

A model program for freshman women in engineering was field tested and evaluated at the Purdue University Department of Freshman Engineering. The course, open to men and women, was designed to provide more equitable educational opportunities through hands-on laboratories, career education, and role-model lectures on energy, environment, transportation, biomedical engineering, and productivity. Six standardized tests were administered to evaluate the effectiveness of the laboratory experiences in increasing knowledge in technical areas. To evaluate changes in goals, interests, attitudes, perceived capabilities, and experiences, a survey was administered. The evaluation instruments were administered before and after the program to two course groups, one containing primarily women and one containing about half women and half men, and to two control groups. The hands-on laboratory resulted in substantial, although not complete, gains in technical knowledge for women in the experimental group compared to men in the control group. Student journals showed evidence that a great deal of thought was going into the formulation of specific career plans after each role-model lecture/discussion session and career counseling session. Increased self-confidence of women in their technical knowledge and laboratory skills was indicated from the survey scales. Final course evaluations by students indicated that they were generally pleased with the course. (SW)

1. A MODEL PROGRAM TO PROVIDE EDUCATIONAL EQUITY FOR WOMEN BEGINNING IN ENGINEERING [1) 2)]

1.1 Abstract

The number and percentage of women who begin and graduate in engineering in the United States has traditionally been very small (less than 1%). However in the mid and late 1970's there have been very significant increases. Women entering engineering, when compared with men, generally have higher average verbal abilities and higher pre-college grades. They are also not as likely to have had mechanical and technical experiences nor are they as familiar with engineering related societal problems. To provide more equitable educational opportunities, a special course was developed at Purdue University to meet these special needs. The course is open to men and women and included:

- hands on laboratories,
- role-model lectures on energy, environment, transportation, bio-medical engineering, and productivity, and
- career planning.

Pre and post tests and surveys indicate significant gains by students participating in the experimental course compared to students in a control group.

1) *Paper prepared by William K. LeBold, Blaine R. Butler, and Marie Knigga for the International Society for Engineering Education 7th International Symposium, Klagenfurt, Austria, June, 1978.*

2) *This project was sponsored in part or in whole by the Department of Health, Education, and Welfare, U.S. Office of Education under the Women's Educational Equity Act, Grant No. 02G007605965. However, the opinions expressed here do not necessarily reflect their position or policy and no official endorsement by the U.S. Office of Education should be inferred.*

1.2 Nature and Purpose

Engineering is one of the largest professions in the U.S., employing over a million engineers in 1970 and U.S. engineering employment is expected to reach one and a half million in the 1980's. However, engineering has been primarily a male profession with less than 1% female, one of the lowest in all U.S. professions and the lowest in the science fields. [3] Nonetheless, women are beginning to enroll in engineering colleges in unprecendented numbers and proportions as can be seen in Table 1. There has been a sevenfold increase in seven years nationally (1181 in 1969 to 8545 in 1976) and even greater growth rates at many institutions, e.g. 1972-77 at Purdue University - a tenfold increase (27 to 284 freshman) in five years. There are similar encouraging signs at the demand level, which have been stimulated in part by affirmative action , equal employment opportunities and legislation. The College Placement Council (1975,76) [4] and university placement centers also indicated that BS graduate engineering women are as likely, or more likely, to seek and be granted job interviews and job offers and report slightly higher mean starting salaries than BS graduate engineering men.

Current studies and studies over the past several years have documented a variety of problems women entering engineering and other non-traditional programs are likely to encounter [5] including both lack of mechanical

3) *National Science Foundation. 1972 Scientist and Engineer Population Redefined, Volume 2, Labor Force and Employment Characteristics, NSF 75-327; Detailed Statistical Tables, Engineers by Field, NSF 76-306, Washington, D.C. 1975.*

4) *College Placement Council, 1973-74 and 1974-75 Salary Studies, Bethlehem, Pennsylvania, 1975, 1976.*

5) *Davis, S.O. and Inter-University Research Group on Women in Engineering, "Academic Experiences of Engineering Students - Does Sex Make a Difference?" University of Minnesota, 1977; also New Engineer, Beyond Tokenism, February 1978.*

TABLE 1

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	N/Avail.	817	10190	284

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

Office of the Registrar, Purdue University knowledge and indecision as to a specific area within their field of interest.[6] Lack of technical knowledge by women in engineering was documented as early as 1962 by Dement.[7] By talking with women entering mechanical engineering, she found that these women encountered difficulties because of the inadequacy of their vocabularies due to differences between their earlier experiences and those of men. Shaycroft (1967).[8] in the Project Talent Study of the growth of cognitive skills during the high school years, provides further evidence of inequities. High school men and women who were tested at both grades 9 and 12, showed substantial differences in several areas of knowledge, which are basic to the study of engineering, including physical science, aeronautics, electronics and mechanics. Furthermore, studies conducted by Erlick and LeBold (1975)[9], and LeBold, Bond, and Richard (1975),[10] indicate that men are much more likely than women to have hobbies, interests and educational experiences which are engineering related and provide technical "hands-on" experiences. It was also found that students who had these experiences, were much more likely to enter scientific fields. Additionally, women who decide to enter engineering, do so at a much later time in high school and are much more likely to be undecided as to a field of specialization.

6) Ott, M.D. Experiences, Aspirations and Attitudes of Male and Female Freshman Engineers, Engineering Education, Washington, D.C. 1965.

7) Dement, A.L. "The College Woman as a Science Major", Journal of Higher Education, 1962, Vol. 33, pp. 487-490.

8) Shaycroft, M.F. Project Talent: The High School Years-Growth in Cognitive Skills, American Institutes for Research, 1967.

9) Erlick, A. & LeBold, W.K. "Factors Influencing the Science Career Decisions of Women and Minorities: Purdue Opinion Poll 101", Purdue University, 1977.

10) LeBold, W.K., Bond, A., & Richard, H. "1974 Purdue Freshman Expectations" Department of Freshman Engineering, Purdue University, 1975.

Based on these findings and related programs designed for women in non-traditional scientific fields at the University of Oklahoma,[11] Cornell,[12] and Purdue;[13] the Purdue University Department of Freshman Engineering designed, field tested and evaluated a model program for freshman women in engineering. The project is funded under a grant from the U.S. Office of Education under the Women's Educational Equity Act (WEEA).

1.3 The four project objectives are:

- To develop an educational model for freshman engineering women which will enable them to participate more fully and more fairly in engineering education.
- To evaluate the effectiveness of the educational materials and program developed including the offering of an experimental course to field test the model.
- To disseminate information nationally regarding the educational materials.
- To collect, store and organize information on studies of and programs for women in engineering at United States universities and colleges.

1.4 Project Status

Purdue's model program is similar in some ways to three other programs which have been developed for women in non-traditional scientific fields.

11) *Pollack, Betty L. and Little, Lee K. "Experimental Project in Physics Education or New Avenues for Women", The Physics Teacher, pp. 39-399, October, 1973.*

12) *Hall, Thomas and Hall, Carol. "Basic Laboratory Skills Course at Cornell" in Proceedings of Women in Engineering...Beyond Recruitment Conference, Cornell University, Ithaca, New York, pp. 89-93, June 22-25, 1975.*

13) *Brown, L.H. "Involvement of students in research", in Proceedings of Women in Engineering...Beyond Recruitment Conference, Cornell University, Ithaca, New Jersey, pp. 98-104, June 22-25, 1975.*

Two of the programs, Oklahoma's "New Avenues" program for women in physics [14),15)] and Cornell's program for women in engineering [16)] included a series of basic laboratory experiences for students in these areas. Purdue's program for women in science [17)] involved the use of role-model lecturers from different areas within science as well as special counselling and an unstructured research experience.

Purdue's WEEA Women in Engineering Program has focused on the development of an experimental course directed at meeting the needs of freshman engineering women, but is open to all students. The program includes both the use of laboratory sessions relevant to engineering and role-model lecturers from within and outside of engineering to discuss various engineering related problems. In addition to this, group and individual counselling sessions are a part of the program.

The primary objectives of the course are:

- To provide laboratory experiences for freshman engineering students, particularly women which include knowledge and "hands-on" skills related to engineering.
- To provide a variety of role-model lecturers for freshman engineering students to help them identify career opportunities and interests in various fields of engineering and to help them develop an understanding of societal engineering problems.

14) Pollack, Betty L. & Little, Lee K., "Experimental Project in Physics Education or New Avenues for Women", The Physics Teacher, pp.39-399, October 1973.

15) Shay, Dennis "New Avenues", Proceedings from Women in Engineering... Beyond Recruitment Conference, pp. 94-98, Cornell, 1975.

16) Hall, Thomas & Hall, Carol. "Basic Laboratory Skills Course at Cornell" in Proceedings of Women in Engineering...Beyond Recruitment Conference, Cornell University, Ithaca, New York, pp. 89-93, June 22-25, 1975.

17) Brown, L. H. "Involvement of students in research" in Proceedings of Women in Engineering...Beyond Recruitment Conference, Cornell University, Ithaca, New Jersey, pp. 98-104, June 22-25, 1975.

- To provide career counseling for freshman engineering students to help them identify their abilities and interests and to integrate this information with their understanding of fields of engineering into meaningful career plans.

- To compare and evaluate the experiences of men and women who participated in the experimental program with similar men and women who did not participate in the program.

1.5. Offering of the Experimental Course

The experimental course which was offered during the spring semester (15 weeks) of 1977, January to May, included a one-hour lecture and a two-hour laboratory each week. Table 2 gives an outline of the lectures and laboratories which were given during the spring semester of 1977. The primary emphasis of the lecture sessions is to present role model speakers from various areas who are concerned with problems of energy, environment, transportation, productivity and bio-medicine. In Figure 1 Gwendolyn Albert from the U. S. Environmental Protection Agency discusses water pollution problems in Texas. The role models included both men

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Insert Figure 1.

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and women, minority and jamority group members, young and old, and signle and married individuals. Some of the speakers were members of Purdue's staff; others were representatives of industry or governmental agencies. Speakers were drawn from various engineering professions as well as from other professions such as psychology, economics and physics, which are concerned with these problems. Figure 2 is Eastman Kodak representative, Lorel Au, explaining the various aspects of her job as an Environmental Engineer.

Insert Figure 2.

TABLE 2

ENGR. 195A/B

Lectures and Laboratories

1. Introduction
2. Initial Testing
3. Lecture: Career Planning I - Christine Smith, Counselor, Freshman Engineering
4. Lab #1: Hand Tools
5. Lecture: Environment - Lorel Au, Eastoman Kodak
   Gwendolynn Albert - Environmental Protection Agency
6. Lab #2: Power Hand Tools
7. Lecture: Environment - Ron Wukash, Civil Engineering, Purdue
8. Lab #3: Power Tools
9. Lecture: Energy: Prof. Gerry Heydt, Electrical Engineering, Purdue
10. Lab #4: Woodwork
11. Lecture: Energy: Prof. R. E. Bailey, Nuclear Engineering, Purdue
12. Lab #5: Electricity
13. Lecture: Energy - Prof. Keith Brown, Management, Purdue
14. Lab #6: Plumbing
15. Lecture: Transportation - Ann Muzyka, Dept. of Transportation
16. Career Planning II - Christine Smith, Counselor, Freshman Engineering
17. Lecture: Transportation - Prof. Alan McDonald & Prof. Raymond Goodson, Mechanical Engineering, Purdue
18. Lab #7: Introduction to Recip. Eng.
19. Lecture: Engineering Design - Blaine Butler, Freshman Engineering
20. Lab #8: Small Engines
21. Lecutre: Bio-Medical - Dianne Rekow, Bio-Medical Engineering
22. Lab #9: Introduction to Automotives
23. Lecture: Bio-Medical - Prof. Leslie Geddes, Bio-Medical Engineering
24. Lab #10: Auto Safety Inspection
25. Lecture: Productivity - Fred Wood, F-16 Project Office, Wright Patterson A
26. Lab #11: Auto Tune-Up
27. Lecture: Productivity - Prof. Harold Amrine, Industrial Engineering
28. Lab #12: Turbine Engines
29. Lecture: Career Planning III - Christine Smith, Counselor, Freshman Engineering

A second major emphasis of Engineering 195 was the career planning and counselling portion of the course. Three career planning sessions were scheduled. The first session which was held at the beginning of the semester, was a combination lecture and discussion emphasizing the interaction of interests, abilities or aptitudes, individual goals, and aspirations especially regarding career choice. These factors were compared to the students' perceptions of what kinds of things an engineer does. The second career counselling session held at approximately mid-semester involved a short lecture about the use and interpretation of the Strong Campbell Interest Inventory [18] and a short lecture about the use and interpretation of the Purdue Interest Questionnaire.[19] Each student had profiles of themselves for both of these interest questionnaires. After the lectures, the students were divided into small groups for further interpretations of their interest inventories. Students were also given the option of discussing their profile individually if they wished to do so. Figure 3 is Christine Smith interpreting the Strong-Campbell Interest Inventory for an Engineering 195 student during a career counseling session.

Insert Figure 3

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18) Strong, Edward K., Jr., and Campbell, D.P. Strong-Campbell Interest Inventory, Stanford University Press, Stanford, California, 94305, 1974.

19) LeBold, W.K., et al. The Purdue Interest Questionnaire, Department of Freshman Engineering, Purdue University, West Lafayette, Indiana, 1976.

During the last session students were given an open-ended assignment in which they were asked to write their biographical introduction to be given at a banquet at which they were to be the principal speaker at age 50. The career counseling was primarily concerned with the decision-making process, which women in particular face when they consider engineering as a career choice and attempt to decide upon an area within engineering.

Student journals, giving their impressions of each class session, were another important aspect of the career planning. Appendices A, B, C, and D give some selected comments students wrote in their journals about the role model lecture-discussions, the hands-on laboratories , the career counselling and the overall course.

A third major area of emphasis of the experimental course was to provide students , with "hands-on" experiences. During a two hour laboratory each week, held at the Purdue Airport, students worked in a variety of activities involving hand tools, power tools, metals, electricity, the assembly and disassembly of small engines, automotives, and a test demonstration of a gas turbine engine. Figure 4 shows an engineering student using a blow torch.

Insert Figure 4

The primary concern of the hands-on laboratory was providing the student participants with knowledge and experiences related to engineering and technology. Another important aspect of the lab is that it gives students more confidence in their ability to work independently and in groups in a laboratory situation. This increased competence hopefully will help students in future courses involving laboratory work. Furthermore, many engineering jobs involve a great deal of experimental laboratory work, so that proficiency at laboratory work is often very important to the practicing engineer. The lab portion of the course progressed very well. The comments from the journals indicate the students' interest and the value of these experiences to their engineering education. Evaluation by upperclass engineering students confirmed the merits of the "hands-on" lab experiences.

1.6 Evaluation of the Educational Program

Two thousand freshman engineering students were given information about the experimental course during the fall semester. Subjects were selected randomly from the 250 freshman engineering and science students (75 women and 175 men) who expressed an interest in the course. The assignment of students in the course included two experimental sections, one containing primarily women (22 women and 4 men actually enrolled) and one containing about half women and half men (15 women and 11 men actually enrolled). Two control groups were used for the study. One control group consisted of persons who had requested the course but were assigned to the control group (15 subjects, 10 women and 5 men participated). The other control group consisted of students enrolled in a freshman engineering design course (61 men and 4 women participated).

1.7 Evaluation Instruments: Six standardized tests were used to evaluate the effectiveness of the laboratory experiences in increasing knowledge in technical areas. These tests include the Tool Knowledge

Test, the Mechanical Information Test, and the Electrical Information Test, [20] the Auto Mechanics Test, [21] the Bennett Mechanical Comprehension Test, [22] and the Purdue Adaptability Test.[23]

To evaluate changes in goals, interests, attitudes, perceived capabilities, and experiences, a survey of 150 items was developed specifically for the program. This Job Activity Preference Questionnaire [24] was used to measure changes in job and activity preferences as a result of the program.

All of the pre-testing including the use of the standardized tests and the survey was completed during the first week of classes. Post-testing with the same instruments was completed during the last week of classes.

A supplementary survey designed for evaluation of various aspects of the course (including the lecturers, laboratories, career counselling sessions, textbooks, etc.) was completed by the experimental students at the end of the semester as well.

1.8 Data Analysis: The data were analyzed using a variety of statistical techniques. The six cognitive pre-tests and post-tests used to evaluate the effectiveness of the laboratory experiences were analyzed using t-tests, analysis of variance and of covariance. The total score based on the sum of the six tests was analyzed as well. The experimental group and control groups gain scores and sex differences were of primary interest in the analyses.

20) Educational Testing Service, Electrical Information Test, Mechanical Information Test, and Tool Knowledge Test, 1961.

21) Campbell, Bruce A. & Johnson, Suellen O. The Short Occupational Knowledge Test for Auto Mechanics, Science Research Associates, 1969.

22) Bennett, George K., Bennett Mechanical Comprehension Test, The Psychological Corporation, 1968.

23) Lawshe, C.H. and Tiffin, J. The Purdue Mechanical Adaptability Test, Purdue Research Foundation, 1946.

24) Mechan, Robert C., Harris, Alma F., McCormic, Ernest J., and Jeanneret, P.R. Job Activity Preference Questionnaire, 1972.

Items on the pre-survey and post-survey were analyzed using chi-square as a statistic in which four groups were compared: experimental men, experimental women, control men and control women. The items were then factor analyzed and made into 10 separate Likert type scales. Reliability co-efficients were obtained for the scales using the pre-survey. The pre-scales and post-scales were separately analyzed with primary interest in gain scores, experimental vs. control groups and sex difference.

1.9 Results - Cognitive Data: As may be seen in Table 3 the combined experimental and male groups had significantly higher adjusted mean scores than control groups on the Purdue Mechanical Adaptability Test, the Mechanical Information Test and the total score based on the analysis of covariance results using the pre-test as a covariate and post-test as the variate. Except for the Mechanical Information Test there were no statistically significant differences between the adjusted means scores of the experimental and control women. Table 4 summarizes the results of testing the significance of the gain scores. Highly significant gains for women in the experimental group were observed on all tests except the Auto Mechanics Test ($p < .001$) with significant and similar results for the combined experimental group ($p < .001$). The experimental men also showed significant improvement on all but the Bennett Mechanical Comprehension. The control groups (men, women and combined) also showed slight gains on most of the cognitive tests. The differences in gain scores using t-tests in Table 5 indicate significantly greater gains on all but one test (the Auto Mechanics Test) for the combined experimental over the

TABLE -3

Analysis of Covariance Significance Levels and Raw Score Adjusted Means for the Tests of Technical Knowledge.

	ADJUSTED MEANS					
	WOMEN		MEN		COMBINED	
	EXPER.	CONTROL	EXPER.	CONTROL	EXPER.	CONTROL
MECHANICAL ADAPTABILITY	32	30	35	31 [2]	33	30 [2]
MECHANICAL COMPREHENSION	55	55	54	53	54	54
TOOL KNOWLEDGE TEST	21	20	23	21	21	21
MECHANICAL INFORMATION	21	18 [3]	23	20 [2]	22	19 [1]
ELECTRICAL INFORMATION	21	19	22	21	21	20
AUTO MECHANICS TEST	5	5	6	5	5	5
TOTAL	156	149	160	149 [3]	157	149 [1]

[1] $p < .05$
[2] $p < .01$
[3] $p < .001$

TABLE 4

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.

COGNITIVE TEST *	GROUPS: EXPER. WOMEN PRE	EXPER. WOMEN POST	CONTROL WOMEN PRE	CONTROL WOMEN POST	EXPER MEN PRE	EXPER MEN POST	CONTROL MEN PRE	CONTROL MEN POST	TOTAL EXPER PRE	TOTAL EXPER POST	TOTAL CONTROL PRE	TOTAL CONTROL POST
PMA	22	27^{3}	21	24	34	39^{3}	32	34^{1}	25	31^{3}	30	32^{2}
BMC	48	51^{3}	49	52	59	59	55	55	51	53^{3}	54	55^{1}
TKT	16	18^{3}	15	17^{1}	25	26^{1}	22	23	18	20^{3}	21	21^{1}
MIT	15	19^{3}	14	14	21	24^{3}	21	22^{1}	16	20^{3}	19	20^{1}
EIT	16	19^{3}	15	17	21	23^{2}	21	22^{1}	17	20^{3}	20	21^{2}
AMT	4	4	3	4^{2}	5	7^{1}	6	6^{1}	4	5^{1}	5	6^{1}
*SUM	120	137^{3}	116	128^{2}	163	178^{3}	156	161^{3}	136	152^{3}	150	157^{3}
No. of Cases	(37)	(37)	(14)	(14)	(14)	(14)	(61)	(61)	(51)	(51)	(75)	(75)

* Cognitive test titles:

PMA - Purdue Mechanical Adaptability Test
BMC - Bennett Mechanical Comprehension Test
TKT - Tool Knowledge Test
MIT - Mechanical Information Test
EIT - Electrical Information Test
AMT - Auto Mechanics Test
*SUM - Total of all (Due to rounding error totals may not be equal)

Signifiance levels based on 1 tailed t-tests:

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

TABLE 5

Raw Score Differences Between Cognitive Pre and Post-Test Means, Differences Between Differences of Experimental and Control Groups, and t-Test Significance Levels for the Differences Between Differences for the Groups

GROUPS

COGNITIVE TESTS	WOMEN EXPERIM $\bar{X}_2-\bar{X}_1$=DE	WOMEN CONTROL $\bar{X}_2-\bar{X}_1$=DC	DE-DC	p	MEN EXPERIM $\bar{X}_2-\bar{X}_1$=DE	MEN CONTROL $\bar{X}_2-\bar{X}_1$=DC	DE-DC	p
PMA	5.7	3.7	2		5.6	1.6	4	2
BMC	2.8	2.4	.4		.29	.61	-.32	
TKT	2.1	1.8	.3		.93	.46	-.47	
MIT	3.9	.9	3.0	2	3.57	.85	2.72	2
EIT	2.6	1.7	.9		2.29	.72	1.57	1
AMT	.65	1.14	-.49		1.79	.59	1.20	
SUM	17.8	11.6	6.2	1	14.4	4.8	9.6	3
N. of Cases	(37)	(14)			(14)	(61)		

TOTAL

COGNITIVE TESTS	EXPERIM $\bar{X}_2-\bar{X}_1$=DE	CONTROL $\bar{X}_2-\bar{X}_1$=DC	DE-DC	p	EXPERIM WOMEN $\bar{X}_2-\bar{X}_1$=DE	CONTROL MEN $\bar{X}_2-\bar{X}_1$=DC	DE-DC	p
PMA	5.7	2.0	3.7	3	5.7	1.6	4.1	3
BMC	2.12	.94	1.18	1	2.81	.61	2.20	3
TKT	1.78	.71	1.07	1	2.11	.46	1.65	2
MIT	3.80	.85	2.95	3	3.89	.85	3.04	3
EIT	2.53	.91	1.62	2	2.62	.72	1.90	3
AMT	.96	.69	.27		.65	.59	.06	
SUM	16.9	6.1	10.8	3	17.8	4.8	13.0	3
N. of Cases	(51)	(75)						

Based on a chi-square analysis of frequencies:

[1] $p < .05$
[2] $p < .01$
[3] $p < .001$

control group and for the experimental women over control men. The experimental women had significantly greater gains that the control women on the Mechanical Information Test ($p < .01$) and on the total score ($p < .05$). Significantly greater gains were also found for the experimental men over the control men on the total and three cognitive measures.

The analysis of variance of the pre and post tests both revealed significant differences according to sex on all tests ($p < .001$). However, significant improvement was found for both men and women in the experimental groups (on the previously mentioned tests) when they were analyzed separately by the analysis of covariance and t-tests. Figure 5 contains a summary profile showing pre and post test results

Insert Figure 5

for experimental women and control men. Although the women were not able to completely "catch up" with the men in technical knowledge, there was a substantial gain.

The chi-square analysis of the pre-survey items revealed that women generally felt they had less technical capability than men. The post survey, however, revealed that women in the experimental group had increased confidence in their technical skills and that they felt they had gained a great deal in their technical knowledge. The analysis of variance of the pre-survey and post-survey scales also showed that the experimental women gained in their confidence in performance of technical skills and in their preceived achievement of technical knowledge. Changes in goals, interests, and attitudes toward women in engineering for all groups were minimal although women

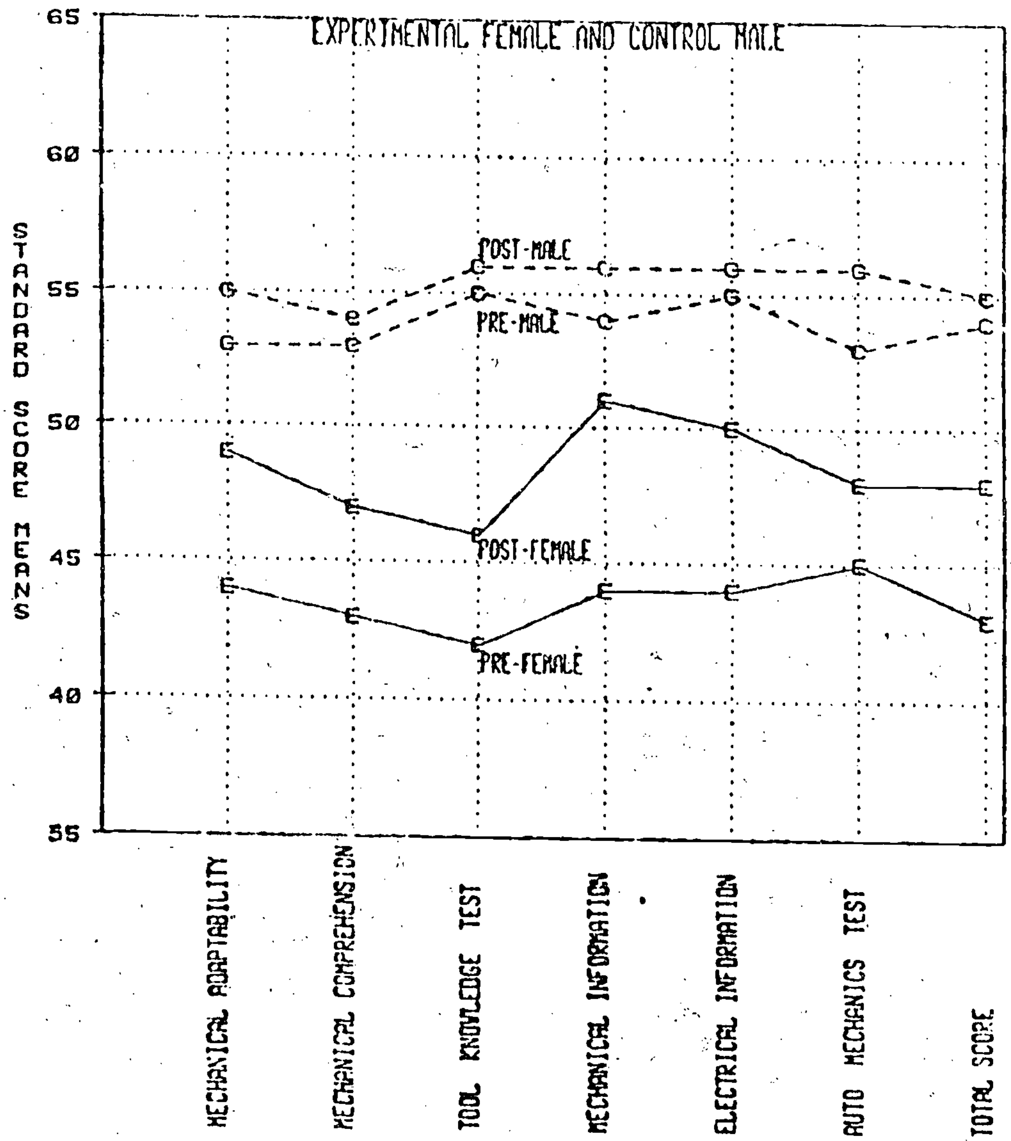

Figure 5. The profile shows the performance of experimental women compared to control men on each of the pre- and post-cognitive tests.

tended to have stronger and more positive attitudes in both the pre-surveys and post-surveys. Table 16 contains mean scores on the pre and post survey for the various scales used to measure the affective and behavioral impact of the program. The very significant gains in self-perceptions of technical capabilities by the experimental women and men provides statistical support for the positive affective impact of the model course. The increased engineering-technical activities of the experimental group is perhaps expected in view of the laboratory experiences. Of continuing interest which is the focus of data now being collected and analyzed is the determination as to whether these gains will continue among the experimental women and men a year or two after the course is completed.

1.10 Discussion

The pilot field test and the model program designed for women entering engineering indicate that a single course can provide women (and men) with those experiences they often lack and which tend to put them at a disadvantage in launching an engineering education. The "hands-on" laboratory resulted in substantial, although not complete, gains in technical knowledge for women in the experimental group compared to men in the control group. Student journals showed evidence that a great deal of thought was going into the formulation of specific career plans, after each role-model lecture-discussion session and career counselling session. Evidence from the survey scales indicates increased self-confidence of women in their technical knowledge and laboratory skills, as well. Final course evaluations by the students indicated that they were generally pleased with the course

TABLE 6

Raw Score Means and T-Test 2 Tailed Significance Levels for Differences Between Correlated Pre and Post Survey Scale Means for Each Group in the Purdue 1977 WEEA Engineering Skills and Career Planning Study.

SURVEY SCALES	EXPER. WOMEN PRE	EXPER. WOMEN POST	CONTROL WOMEN PRE	CONTROL WOMEN POST	EXPER. MEN PRE	EXPER. MEN POST	CONTROL MEN PRE	CONTROL MEN POST	TOTAL EXPER. PRE	TOTAL EXPER. POST	TOTAL CONTROL PRE	TOTAL CONTROL POST
Educational Goals - Importance												
Hands-on Skills	13	13	11	11	13	12	11	11	13	13	11	11
Knowing About Engineering Problems	31	31	30	29	30	29	29	28 [2]	31	30	29	28 [1]
Career Plans & Self Identity	15+	15- [1]	15	15	15	14 [1]	15	13	15	14 [2]	15	14 [1]
Educational Goals - Achievement												
Hands-on Skills	13	12	6	7	12	11	8	9	13	12	8	8
Knowledge About Engineering Problems	26	28	20	22	27	26	23	23	26	27	23	21
Career Plans & Self Identity	12	12	11	11	14	12 [1]	12	11 [2]	13	12 [1]	12	11 [2]
Capabilities												
Sensory Skills	27	29 [1]	29	28	29	30	28	28	28	29	30	28 [2]
Psycho-Motor Skills	56	59 [1]	57	54	62	61	61	58	57	60	60	57 [2]
Mechanical Equipment Adjusting	34	37 [3]	34	35	39	38	36	35	35	37 [1]	35	35
Observational Skills	32	34 [2]	32	32	39	37	35	34	33	35	34	34
Personal & Social Development	12	14 [2]	12	13	12	12	11	12 [3]	12	13 [1]	11	12 [3]
Preferences												
Engineering	23	24	23	24	27	26	24	24	24	25	24	24
Activities												
Engineering & Science Discussion	37	45 [3]	38	40	37	44 [1]	37	38	37	45	37	38
Tools and Technology	19	35 [3]	18	20	26	32 [1]	24	24	21	34 [3]	23	23
Engineering & Science	18	21 [2]	18	20	22	23	18	21 [3]	19	21 [1]	18	21 [3]
Engineering & Science Programs	8	11 [3]	9	9	10	13	9	11 [3]	9	12 [3]	9	11 [3]
Women in Engineering Attitudes												
Competitiveness	55	54	58	53	47	46	46	41 [2]	53	52	49	44 [3]
Femininity	21	20	21	20	16	15	15	15	19	19	16	16
Leadership	18	17	19	17 [1]	14	14	14	13 [2]	17	16	15	14 [3]
Career Planning	13	14	14	13	13	13	13	12 [2]	13	13	13	12 [3]
Total Scores												
Importance of Goals	59	59	57	55	58	55	55	52 [3]	59	58	55	52 [3]
Achievement of Goals	51	52	38	40	53	50	44	43	51	51	42	[illegible]
Technical Capability	148	159 [3]	151	150	168	164	161	154 [1]	154	161	159	154 [1]
Engineering-Technical Activities	82	112 [3]	82	89	95	111	88	94 [3]	86	112 [3]	87	93 [3]
Women in Engineering Attitudes	94	92	98	90	78	75	76	70 [2]	89	87	80	74 [3]
No. of Cases	(35)	(35)	(15)	(15)	(13)	(13)	(63)	(63)	(48)	(48)	(78)	(78)

Based on student and staff observations and evaluations, revisions were made in the pilot course and offered again during the 2nd Semester 1978. The course was changed primarily to more nearly meet the individual needs of the students. It was divided into modules including the "Hands-on" lab, the role-model lecture-seminar, and a recitation-discussion which includes engineering problems and career counselling. Students can select a single or combination of modules that meet their individual needs. The career counselling-discussion module was reserved primarily for those people who were undecided. Students who were interested in the course filled out a form rating their knowledge of engineering problems, technical knowledge, and choice of school. Students were given priority on the basis of their ratings, so that students with the greatest need would have the first chance to sign up for the course. Space was reserved for twice as many students (120 vs. 60) as the previous year, but only about half of those who indicated an interest (150 of 300) could be accommodated.

The staff anticipates even greater success with the modular approach. Present plans indicate the University will continue to offer the "hands-on" laboratory both semesters during the academic year and the seminar and career counselling-recitation modules during the second semester of the academic year.

The results of the first year's experiences were shared with other colleagues concerned with womens programs in engineering and higher education at an invitational workshop held at Purdue, December 1-2, 1977. Press releases, the annual report and technical papers presented at local, regional, national [25) 26)], and international meetings

25) *Butler, B., et al "Engineering Hands-On Skills", paper presented at the 85th Annual American Society of Engineering Education Conference, University of North Dakota, June 27-30, 1977.*

26) *LeBold, W.K., et al "Career Preparation Model: Educational Equity in Engineering Annual Report, September 1976 - August 1977, Purdue University.*

have also been used to disseminate information regarding the model program. It is anticipated that other institutions and non-traditional fields will adopt similar, but probably not identical programs depending on their individual needs and resources.

The results of the evaluation of the second year of the project will be incorporated into a comprehensive technical report, a short summary report and in a variety of audio-visual modes.

LIST OF FIGURES

Figure 3. Christine D. Smith interpretes the Strong-Campbell Interest Inventory for an EVGR.195 student during a career counseling session.

Figure 2. Lorel Au from Eastman Kodak explains the various aspects of her job as an Environmental Engineer.

Figure 4. Freshman engineering student uses a blow torch to solder a fitting on copper tubing in the "hands-on" laboratory.

Figure 1. Gwendolyn Albert from the U.S. Environmental Protection Agency discusses water pollution problems in Texas.