2006-2294: GENDER PERSPECTIVES ON THE OPTIMIZATION OF THE INTERDISCIPLINARY COURSE CURRICULUM “INTRODUCTION TO ELECTRICAL ENGINEERING FOR NON-MAJORS”

Kedmon Hungwe, Michigan Technological University

is with the Department of Education, Michigan Technological University. He received his Ph.D from Michigan State University in 1999. His research interests focus on teaching and learning in school, college and workplace contexts.

Seyed Zekavat, Michigan Technological University

is with the Department of Electrical and Computer Engineering, Michigan Technological University. He received his Ph.D from Colorado State University, Fort Collins, Colorado in 2002, in Telecommunications. He has over 10 years of teaching and research experience both in the United States and abroad. He has published more than 50 journal and conference papers, and has co-authored two books and invited chapters published by Kluwer Academic Publishers and Springer.

Glen Archer, Michigan Technological University

is with the Department of Electrical and Computer Engineering, Michigan Technological University. He received his Masters degree from Texas Tech University in 1986. He has been the instructor of an EE service course and its associated laboratories since Fall 2001, and has 12 years of teaching experience.

Gender Perspectives on the Optimization of the Interdisciplinary Course Curriculum "Introduction to Electrical Engineering for Non-Majors"

Abstract

This paper is the outcome of a project that evaluates and improves the curriculum and teaching approach to the interdisciplinary course "Introduction to Electrical Engineering (EE) for non-EE majors" that is taught as a service course at Michigan Technological University, and has equivalents in almost all engineering schools nationally. In order to specify the general and special needs of all non-EE majors and form a curriculum, a comprehensive survey was designed and distributed to universities and industry.

This paper analyses the survey in detail to compare the perspectives of female and male respondents. Specifically, we analyze the impact of prior experience such as research and co-op/internship on how women rate the importance of different curriculum topics. The results show that there are statistically significant differences on 22% of the curriculum topics surveyed. These differences are more critical for females than men. The results will help the development of curriculum content and instructional strategies that are responsive to gender differences. The topic is of crucial importance because of the national concern about the recruitment, retention, and performance of women in the engineering fields.

1. Introduction

The paper is the outcome of a project that evaluates and improves the curriculum and teaching approach to the interdisciplinary course "Introduction to Electrical Engineering (EE) for non-EE majors" that is taught as a service course at Michigan Technological University, and which has equivalents in almost all engineering schools nationally. In order to specify the general and special needs of all non-EE majors and form a curriculum, a comprehensive survey was designed and distributed to universities and industry. The survey outcomes were analyzed to extract and create a proposal for an optimized curriculum. [1] The optimization was performed by addressing the general needs of all majors and the special needs of the diverse engineering fields served by the course. An analysis of the data revealed significant differences in the ways male and female respondents rated the importance of several curriculum areas that were surveyed.

The paper presents an analysis of the differences in the perspectives of male and female respondents, as well as the background factors that are associated with the responses. The topic is of crucial importance because of the national concern about the recruitment, retention, and performance of women in the engineering fields.[2,3] Women earn a disproportionately lower share of the awarded engineering degrees and also have lower retention rates than males.[4] A gender perspective is essential because of the nationally recognized need to increase the proportion of women in engineering.[5] The percentage distribution of engineering degrees conferred to females in 1996-97 was 1.9 percent of all majors. For males the proportion was 12 percent.[6] The paper discusses how these findings have informed the development of new curriculum content, and the methods of teaching the optimized curriculum. The emerging curriculum proposal is designed to emphasize: (1) Application of theoretical concepts through real world case studies drawn from the diverse engineering fields, (2) The use of multiple instructional delivery strategies that include lectures, laboratory work, online instruction, and multimedia delivery, and (3) Tutorial support for students.

Section 2 introduces the background of our activities including the methodology of the study and structure of the survey. Section 3 presents the survey outcome data analysis. Section 4 discusses the results of our analysis and Section 5 concludes the paper.

2. Background

A key mission of university baccalaureate engineering programs is to develop and offer interdisciplinary coursework that is essential to preparing highly-qualified engineering graduates who will be successful and productive in their future careers. To this end, it is generally recognized in the academic environment that an introductory course in EE should be offered to the non-electrical engineering (non-EE) students. As a result, almost all engineering institutions offer at least one "service course" for non-EE majors through the EE department. It is the responsibility of the academic programs to ensure that these service courses remain relevant to the real world of engineering that their graduates will encounter.

Traditionally, the content of the EE service course is a cut-and-paste combination of some of the content of courses offered to EE students. This practice is not consistent with growing interdisciplinary technology and it does not adequately fulfill students' future needs. The traditional approach covers some limited topics in EE in detail but does not cover the broad range of technologies in the field of electrical engineering.

At Michigan Tech, the experience of faculty, along with routine course evaluations by students, show that: (1) students are concerned with the current curriculum that covers topics more extensively than needed, (2) there is no clear link between the subjects taught and the students' fields of study, (3) many of the topics are soon forgotten because they do not apply to the students' fields, and, (4) the course does not cover many topics that the students and practicing professionals believe are relevant to their future careers. The study was conducted in two steps: First, we conducted a preliminary study on the weakness of the current approach in teaching of the interdisciplinary course; then we conducted a comprehensive study in order to develop an optimized version for the course curriculum. The optimized course includes relevant topics at an appropriate level of detail and features web-based materials where feasible.

The following set of questions summarizes the concerns that we have outlined:

1. What concepts, covered to what level of detail, should be included in the education of students of various engineering disciplines to prepare non-EE engineers to efficiently solve the interdisciplinary problems in today's scientific and engineering environment?;
2. Are the current approaches used to teach service courses for non-EE majors in harmony with the goals of nationally recognized organizations that dedicate part of their mission to the improvement of engineering education? Among these organizations are the National

Science Foundation (NSF)[7], the Accreditation Board for Engineering Technology (ABET), [8-10] the National Research Council's Board on Engineering Education,[11,12] and the American Society for Engineering Education, [13,14] and the themes of "application of emerging technologies" and "education for manufacturing"? [11];
3. Will current teaching strategies be able to keep pace with emerging technologies and their related instructional requirements?[15]
4. Given that students' motivation increases if they understand why they should learn a topic, how can they be motivated to engage and master concepts not directly related to their chosen field? [16,17];
5. Given that women earn a disproportionately lower share of the awarded engineering degrees and also have lower retention rates than males[4,5], are there significant gender differences in the perspectives of male and female to specific EE topics? What background factors influence how women respond to specific EE topics

A panel of experts made up MTU faculty from different engineering fields and departments developed a survey questionnaire that included a wide spectrum of topics that they considered relevant to their fields. The experts were forming the following fields: Civil/Environmental, Mechanical/Industrial/Manufacturing, Chemical/Petroleum, Biomedical, and Materials engineering. A questionnaire made up of 21 curriculum areas, was drawn up (see table 1). Each curriculum area was made up of a set of topics. For example, the curriculum area *Safety Topics* was made up of 4 topics which are (1) *Explosive Environments*, (2) *Electric Shock Hazards*, (3) *Environmental RF Hazards*, and (4) *Safety Implications of the National Electric Code (NEC).* The respondents were asked to rate the set of topics surveyed on a scale of 1 to 4 ('not relevant' to 'relevant'). The survey was placed on-line, and its website URL was submitted to other universities, industry and organizations within the US.

Table 1: Curriculum area and topics surveyed

Curriculum area	Topics
1. Safety topics	Explosive Environments, Electric Shock Hazards, Environmental RF Hazards, Safety Implications of the National Electric Code (NEC)
2. Elements and sources	Voltage sources, Current sources, Dependent sources, Resistors, Capacitors, Inductors/Transformers
3. Circuit analysis	DC, DC Transients, AC Transients, AC Steady State, Node Voltage Analysis, Thevenin and Norton Equivalents, AC Power
4. Advanced analog systems	Illumination, Impedance Matching, Amplifiers, Grounding techniques,
5. Three phase power	Delta, Y-Delta
6. Discrete electronic devices	Diodes, BJT Transistors (Bipolar Junction Transistor), FET Transistors (Field Effect Transistor)
7. Analog devices	Op Amps (Operational Amplifiers), Voltage regulators, DC - DC converters, Voltage to Frequency converters, Phase Locked Loops, Interface Devices, Analog Multiplexers
8. Frequency analysis	Fourier series and Transform, Laplace Transform
9. AC motors	Induction Motors, Synchronous Motors
10. Energy conversion topics	DC Motors, Motor-Generators, Power Transmission systems, Photo-Voltaic systems, Electro-Chemical systems, Electro-Thermal systems
11. Basic digital systems	Binary Number System, Digital Logic, Logic Devices (AND, OR, INVERTER), Combinatorial Logic (Memory-less logic systems), Synchronous Logic (Systems with memory)
12. Advanced digital	A/D and D/A conversion (Analog to Digital & Digital to Analog), Embedded

Table 1: Curriculum area and topics surveyed

systems	microprocessors, Digital signal Processing, Automated Test Equipment
13. Computer based instrumentation systems	Data Acquisition, Interfaces, GPIB (General Purpose Interface Bus), TCP/IP (Transmission Control Protocol/Internet Protocol)
14. Various sensors	Pressure, Acoustic, Acceleration, Strain/Load Cells, Linear Variable Displacement Transformers (LVDT)
15. Temperature sensors	Thermistors, Thermocouples, Resistive Temperature Detector (RTD)
16. Lab instruments	Oscilloscopes, Multimeters, Function Generators, DC /AC power supplies, Spectrum Analyzers
17. Lab software	Matlab, Simulink, Mathematica, Orcad, P-Spice, Labview
18. Control and electromagnetic topics	Electromagnetic fields, Microwave systems, Micro-electromechanical systems (MEMS), MEMS Manufacturing, Industrial Control systems, Electromagnetic Compatibility (EMC), Electromagnetic Interference (EMI)
19.Communication systems	Point-to-Point Terrestrial, Satellite, Wireless,
20. Antennas	Fixed, Conformal, Phased Array, Synthetic Aperture
21. Remote sensors	MRI (Magnetic Resonance Imaging), CAT (Computer Assisted Tomography), Ultrasound, Radar, UWB (Ultra-Wide Band), Optical Remote Sensors

3. Analysis

The analysis in this paper is based on responses from total of 382 men and 124 women who returned survey questionnaires. The proportion of women included in the sample is 24.5 percent. Tables 2 and 3 summarize the sample gender and status, and by gender and field. Data from non-engineers (or those who did not indicate their field) was excluded from the analysis. The breakdown by status indicates that the sample broadly represents the stakeholders (that is, students, faculty, and engineers working in industry, as consultants and as government employees). Within the targeted fields, the sample representation of Materials Engineering is minimal.

Table 2: Breakdown of sample by status and gender

		STATUS						Total
Gender		Undergrad	Grad	Faculty	Industrial	Consul.	Gov.	
	Male	74	40	117	96	40	15	382
	Female	48	19	12	28	12	5	124
Total		122	59	129	124	52	20	506

Table 3: Breakdown of sample by field and gender

		FIELD					Total
Gender		Civil	Mechanical	Chemical	Materials	Biomedical	
	Male	113	155	61	7	46	382
	Female	25	31	18	3	46	123
Total		138	186	79	10	92	505

Gender was one of the variables included in the survey. In addition to that, we explored the influence of a set of other background factors, including:

1) The *field* in which the respondent was studying or working: The fields that were included in the survey were Mechanical Engineering/Industrial/Manufacturing, Chemical Engineering/Petroleum, Civil/Environmental Engineering, and Biomedical engineering. The category 'Other' was also included for respondents who did not fit into the categories listed, but has not been included in this analysis.
2) The *status* of the respondent: Status designated the following possible options: undergraduate students, graduate students, faculty/academic, industrial employees, government employees, and consulting/self-employed.
3) Experience with *co-operative (co-op) or internship*: Co-ops and internships involve partnerships between academic institutions and the world of work. For students, this provides a blend of theory and application, new skills and knowledge, and opportunities to learn what to expect in a career in engineering.[18] Respondents were requested to indicate if they had participated in a co-op program, an internship, or a research project as an undergraduate student. We expected that co-op or internship experiences would influence how respondents perceived an EE course, particularly for student respondents.
4) Taking a course in *Electrical Engineering*: In addition, respondents were asked if they had taken a dedicated undergraduate course in Electrical Engineering. We anticipated that the experience (or lack of it) would influence their perception of the value of the course.
5) The final variable was *undergraduate research* experience. We will discuss each of these in turn.

The data was analyzed using the Generalized Linear Model (GLM) of the Statistical Package for the Social Sciences (SPSS).[19] The surveyed topics form the outcome variables in this analysis. For example, under *temperature sensors*, the responses to each of the following were analyzed separately: *Thermistors, Thermocouples,* and *Resistive Temperature Detector (RTD)*. The independent variables that were included in the model of analysis were: *Gender, Status, Field, Co-op/internship experience* (yes, no), and *EE-course* (yes, no). The statistical procedure uses an Analysis of Variance (ANOVA) to determine the impact of each of the variables on the response.[20] It also analyzes the interaction between independent (predictor) variables. For example, significant interaction effects between the independent variables 'gender' and 'internship/co-op experience' would indicate that there are differences on the impact of internship/co-op experience that depend on gender.

4. Results

In this section, we highlight several topics for which statistically significant gender related effects were observed. A level of significance of $p < 0.05$ was used to determine the significance of effects throughout. The effect of gender was mostly observed in the interaction with other background variables. Table 4 lists the curriculum areas and topics for which statistically significant effects were observed. The topics in which we observed significant gender difference form 22% of the total topics surveyed (see Table 1). Here, we discuss the details of the observed effects considering factors such as field, status, whether they have taken the EE course or not, as well as internship, research and co-op experiences.

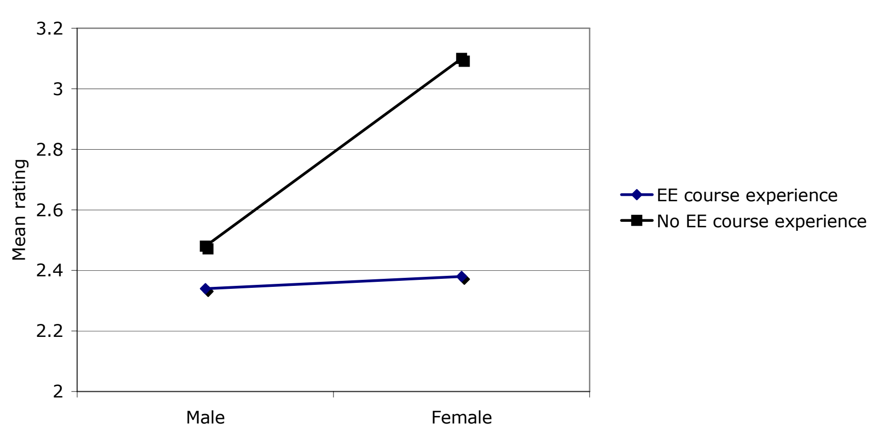
Table 4: Curriculum areas and topics were some significant gender effects were observed

Curriculum area	Topics
Safety topics	Explosive Environments, Environmental RF Hazards, Safety Implications of the National Electric Code (NEC)
Circuit analysis	DC, Node Voltage Analysis, AC Power
Analog devices	Voltage to Frequency converters
Frequency analysis	Fourier series and Transform, Laplace Transforms
Energy conversion topics	Motor-Generators
Basic digital systems	Combinatorial Logic (Memory-less logic systems), Synchronous Logic (Systems with memory)
Advanced digital systems	Automated Test Equipment
Computer based instrumentation systems	GPIB (General Purpose Interface Bus), TCP/IP (Transmission Control Protocol/Internet Protocol)
Control and electromagnetic topics	Electromagnetic fields, MEMS Manufacturing, Electromagnetic Compatibility (EMC)
Remote sensors	MRI (Magnetic Resonance Imaging), CAT (Computer Assisted Tomography), Ultrasound, UWB (Ultra-Wide Band)

Safety topics

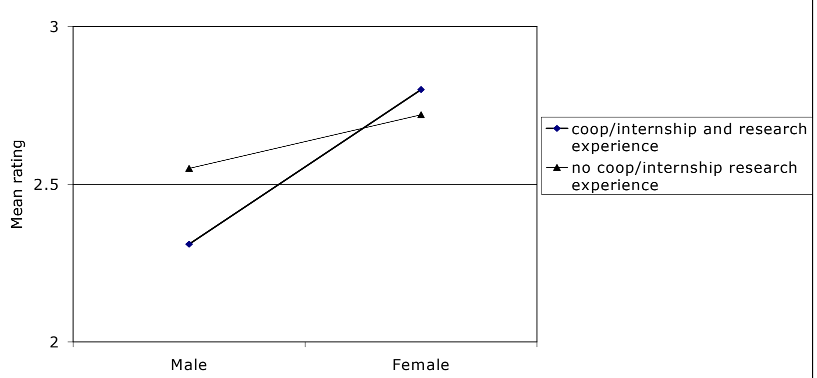
Gender effects were identified on the following topics: *Explosive Environments*, *Environmental RF Hazards*, and *Safety Implications of the National Electric Code (NEC)*. Women and men rated the topic *Explosive Environments* the same when they had taken a dedicated Electrical Engineering (EE) course. Both men and women who had *not* taken such a course rated the topic higher than those who had, but the margin of difference was higher for women. Thus, the impact of a prior EE course experience was to *decrease* the rating (See Figure 1). The outcome was not dependent on that status of the respondent (i.e., whether they are student, employee, etc.).

Figure 1: Respondents with and without an EE course experience: Explosives



There was an overall gender difference in the response to *Environmental RF Hazards* (see Figure 2). The response of women was significantly higher than that of males. Women with co-op/internship background experience gave this topic the highest ratings.

Figure 2: Co-op/internship and research experience: RF Hazards



With respect to the *Safety Implications of the National Electric Code (NEC),* in average there were no difference between men and women. However, when we ran data considering the impact of the co-op experience we observed differences just in men. Males who had a co-op/internship experience rated this topic the lowest, and those who had no co-op/internship rated it significantly higher. Co-op/internship experience is therefore associated with a lower rating of *NEC* for men.

Overall the data indicates gender differences in the rating of *safety topics*. The impact of background experiences on the responses of males and females was mixed. In some cases, the impact of background experiences such as internship/co-op is to reduce the appeal of certain topics for men or women. Similar trends are observed with other topics surveyed as will be discussed in the next paragraphs.

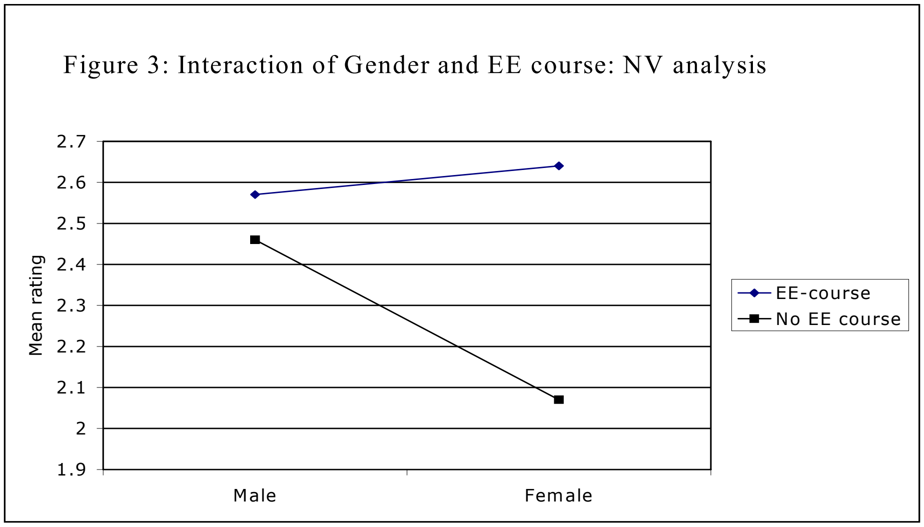
Circuit analysis

Gender effects were observed for the topics *DC*, *Node Voltage Analysis* and *AC Power*. Women with co-op experience rated the topics *AC power* and *DC* higher than those who did not have co-op/internship experience.

Figure 3 shows that the rating of *Node Voltage analysis* for males and women with prior EE course experience was about the same. However, when women had *not* taken a dedicated EE course, their rating on of the topic was significantly lower than that of equivalent males.

Analog devices

There was a gender effect on the response to the topic *Voltage to Frequency Converters.* The highest rating of the topic was from women with a co-op/internship background experience. The rating did not depend on the status of the respondent.

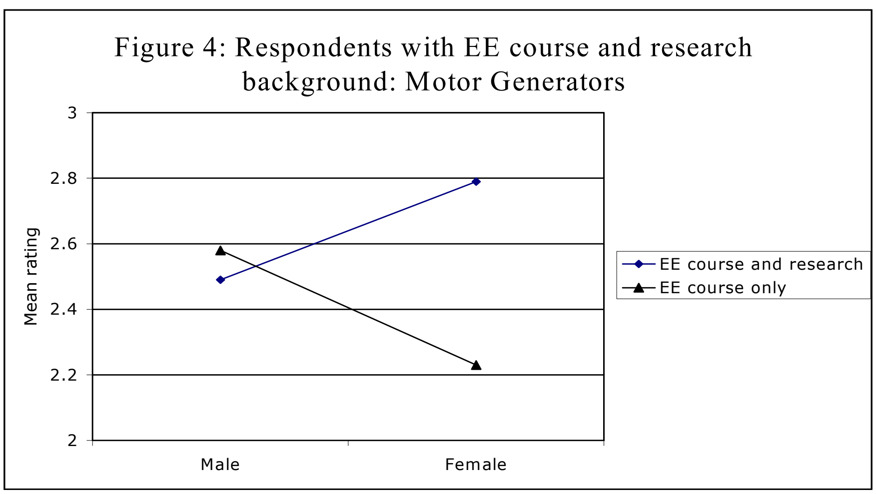


Frequency analysis

Gender effects were observed on the topics *Fourier series and Transforms.* The results depended on gender and status. Undergraduate women who had co-op/internship background rated both topics higher than those who did not.

Energy conversion topics

Women with both an EE course and research background rated the topic *Motor Generators* higher than males with the same background (see Figure 4).



Basic digital systems

Women with research experience background rated both *Combinatorial Logic* and *Synchronous Logic* marginally higher than those who did not except for women faculty who rated the topics lower. The results for males were the opposite, that is, research experience was associated with lower ratings for males (see Figure 5).

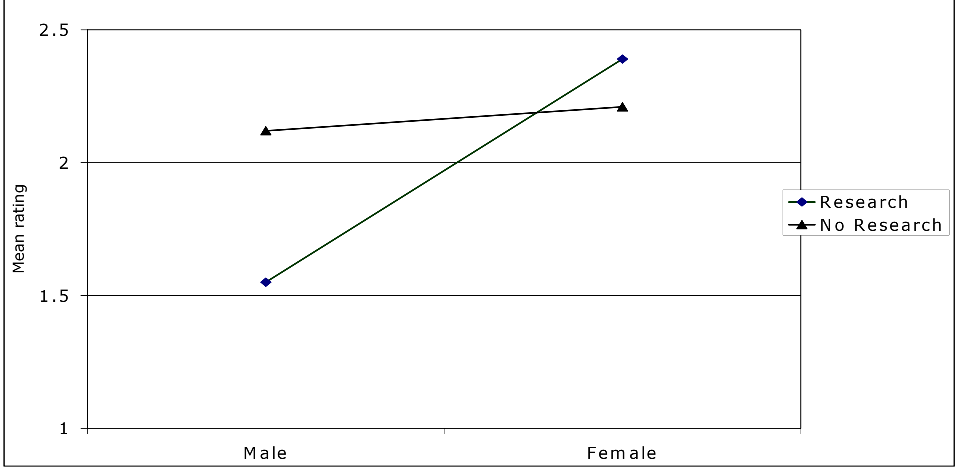


Figure 5: Respondents with research experience: Synchronous Logic

Advanced Digital Systems

Women with an EE course background rated the topic *Automated test equipment* higher than those who did not.

Computer Based Instrumentation

The results depended on gender and status. Undergraduate women with an EE course background rated the topics *GPIB (General Purpose Interface Bus),* and *TCP/IP (Transmission Control Protocol/Internet Protocol)* higher than those who did not.

Control and electromagnetic topics

The relevant topics were: *Electromagnetic fields*, *MEMS Manufacturing*, and *Electromagnetic Compatibility (EMC)*. The rating of the topic *Electromagnetic fields* was higher for men than women irrespective of experience (see Figure 6).

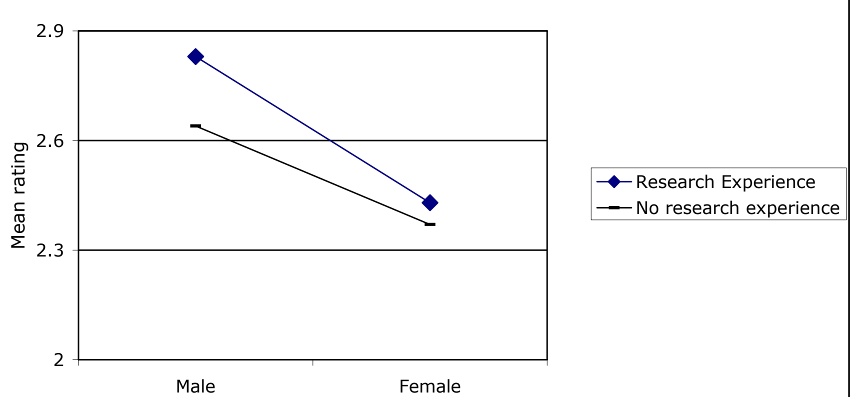
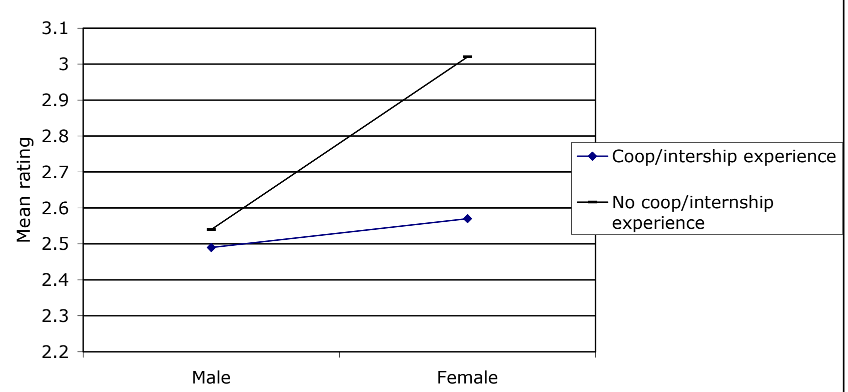


Figure 6: Respondents with with and without research experience: Electromagnetic fields

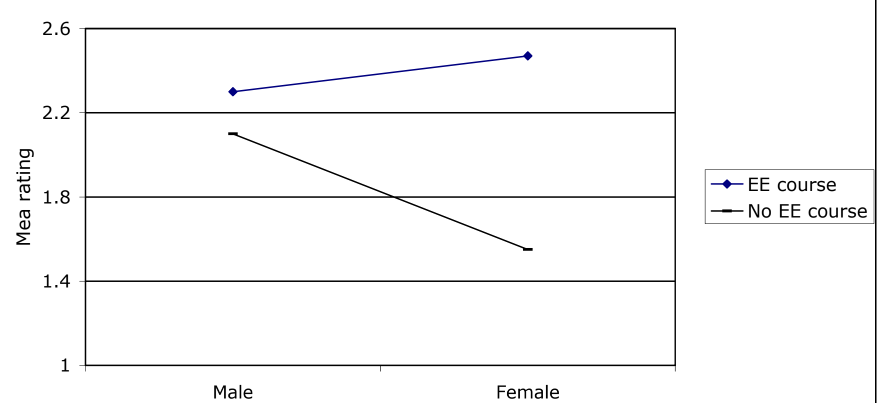
The effect of co-op/internship was to reduce the rating of the topic *MEMS manufacturing* for women. The same variable had no significant impact on males (see Figure 7).

Figure 7: Respondents with coop experience: MEMS Manufacturing



The rating of the topic Electromagnetic Compatibility (EMC) was higher for both men and women when they had an EE course background. However, the change was larger for females as shown in figure 8.

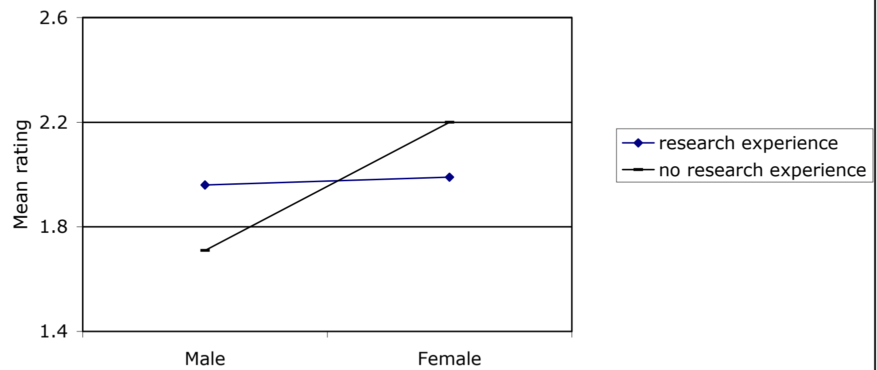
Figure 8: Respondents with EE course:Electromagnetic Compatibility (EMC)



<u>Remote sensors</u>

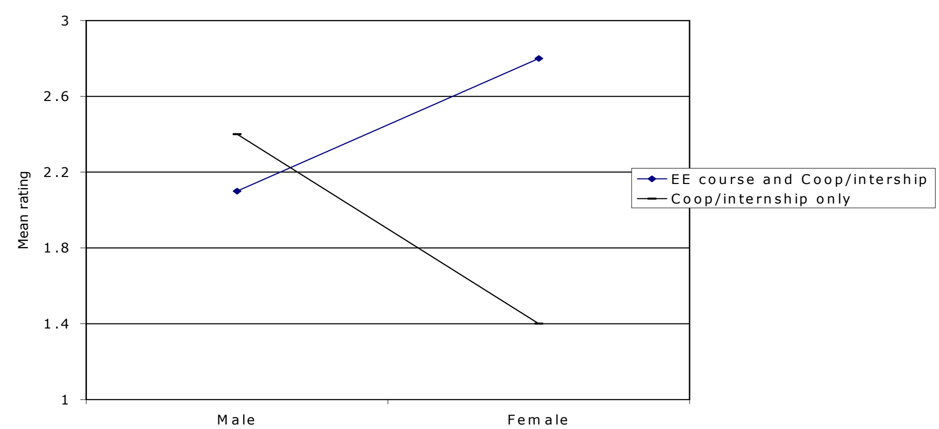
The relevant topics were *MRI (Magnetic Resonance Imaging), CAT (Computer Assisted Tomography), Ultrasound*, and *UWB (Ultra-Wide Band)*. On the topic *UWB*, women with research experience rated the topic less than women without this experience. Men with research experience rated the topic higher than those who did not have research experience.

Figure 9: Respondents with coop experience: UWB



On the topic *ultrasound*, there were marginal differences between males with and without an EE course background. However, EE course background was a significant predictor of female response. Women with an EE course background rated the topic ultrasound higher than those who did not.

Figure 10: Respondents with coop experience: Ultrasound



The impact of research was larger on males than females. Males with research experience rated the topic higher than females. The topic received the highest rating from women with both co-op and EE course experience.

For *MRI* females with research experience rated the topic significantly higher than those who did not. These results were consistent with men’s, and there were no significant gender differences. Women who had research background experience rated the topic CAT lower than those who did not. The opposite was true for males.

As a conclusion to our observations, some statistically significant differences were found between women versus men. These differences are a function of factors such as prior experience with a dedicated EE course, internship/co-op experience, research experience, and status of respondent. Specifically for women we observed that: (1) internship/co-op experience was associated with higher ratings for *AC* and *DC analysis*, *analog devices* and *frequency analysis*, and with lower ratings for *MEMS*; (2) Research experience was associated with higher ratings for *motor and generators* and *MR*I, and with lower ratings for *UWB* and *CAT*; (3) A prior EE course experience was associated with higher ratings for *node-voltage analysis, motor and generators, advanced digital systems, and EMC/EMI*, and with lower ratings for explosive devices; and finally, (4) a prior EE course plus co-op/internship and research was associated with higher ratings for *ultrasound* systems.

5. Conclusions

The findings point to some significant gender differences in how EE related topics were perceived. The effect of prior experience on ratings was generally less on men compared to women. In general, prior experience was associated with higher ratings of topics by women than by men. We believe that the effect of experience is to help students to appreciate topics in Electrical Engineering because they are able to make connections between the curriculum and real world applications. Furthermore, the impact of prior experience appears to be greater on women than on men, and women appear to be much more interested in learning topics when they understand why they should learn them. As a result, it would be important to modify the way topics are presented to women, in order to make better connections of the topics and their applications, for example, by adding more examples and case studies. The findings therefore indicate the effects of gender do not, by and large occur independently, but were influenced by other experiences.

The study reported in this paper is part of a larger project to optimize an interdisciplinary course for non-majors.[2] A curriculum has been created that is taught through: a) lectures, b) a set of web-based modules designed to meet the diverse needs of the different engineering fields, c) and laboratory work. A set of case studies has been developed and will be used to illustrate concepts and applications throughout the course. The curriculum has been pilot tested during Spring 2006 at Michigan Tech University. A key component of the curriculum is the use of case studies that illustrate the application of EE principles and concepts in the different engineering fields. The goal of using case studies is to make the links between theory and practice more explicit with a view to motivating learning and encouraging understanding. The overall aim is to build linkages between theory and practice in a systematic way throughout the student's course work experience.

Acknowledgement

This work is supported by the US NSF Engineering Education Award EEC – 0415962.

References

[1] S. A. Zekavat, K. Hungwe, and Sheryl Sorby, "An optimized approach for teaching the interdisciplinary course electrical engineering for non-majors, " proceedings *2005 American Society of Engineering Education Annual Conference, ASEE'05*, Portland, Oregon, June 12-15, 2005.

[2] A. M. Barker, Effects of gender on engineering career commitment. *Journal of Women and minorities in science and engineering*, Vol. 7, 2001, p. 125-152

[3] R. M. Felder, G. N. Felder, M. Mauney, C. Hamrin, Jr., and E. Dietz, "A longitudinal study of engineering student performance and retention: Gender differences in student performance and attitude." *Journal of Engineering Education*, vol. 84, no. 2, 1995, pp.151-163; Robinson, D. A. G., B. A. Reilly, "Women engineers: A study of educational preparation and professional success." *Journal of Engineering Education*, vol. 82, no. 2, 1995, pp.78-82.

[4] Bell, A. Stereotype threat and women's performance in engineering. *Journal of Engineering Education,* October 2003, Vol. 92, no. 4

[5] Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. *Land of Plenty: Diversity as America's Competitive edge in science, engineering and technology*, September, 2000

[6] U.S. Department of Education, National Center for Educational Statistics. *Trends in educational equity of girls and women NCES 2000-030*. US Government Printing Office, 2000.

[7] R. M. Felder and R Brent, "Designing and teaching courses to satisfy the ABET engineering criteria," *Journal of Engineering Education*, Vol. 92, No. 1, pp. 7-18, Jan. 2003.

[8] B. K. Hodge, R. P. Taylor, "development and evolution of an energy systems design course," *Proceedings the 3rd Conference on Engineering Education*, Vol. 2, Portsmouth, England, pp. 241-245, Sept. 1992.

[9] *Proceedings of the National Congress on Engineering Education*, Accreditation Board for Engineering and Technology, 1987.

[10] S. Sarin, A plan for addressing ABET criteria 2002 requirements, Proceedings *1998 Annual Meeting,* American Society for Engineering Education.

[11] F. T. Najafi and I. Tag, "New trends and context for change in engineering education," *Proceedings 1995 ASEE annual conference*, pp. 944-949, Anaheim, CA, June 25-28, 1995.

[12] *Engineering Education and Practice in the United States-Foundations of Our Techno-Economic Future*, National Research Council, 1985.

[13] *Quality of Engineering Education*, American Association for Engineering Education, 1986

[14] *National Agenda for Engineering Education*, American Association for Engineering Education, 1987.

[15] R. F. Mager, *Preparing Instructional Objectives*, Pitman, CA, 1975.

[16] D. M. Pai and R. A. Deblasio, "Enhanced learning from an industry-university partnership," *Journal of Industry and higher education*, pp. 224-228, Aug. 1997.

[17] D. A. Kolb, *Experiential learning: Experiences as the source of learning and development*, Prentice-Hall, Englewood Cliffs, NJ, 1984.

[18] J. Burtner & S. Barnett, "A preliminary analysis of employer ratings of engineering co-op students. *Proceedings of the American Society for Engineering Education.* South Eastern Regional Conference. Industrial Division, 2003.

[19] A. Dobson, *An introduction to generalized linear models.* Chapman & Hall, NY, 2002.

[20] J. R. Turner & J. F. Thayer, *Introduction to analysis of variance*. Sage, Thousand Oaks, CA, 2001.