AC 2012-4444: IMPLEMENTATION OF COOPERATIVE LEARNING TECHNIQUES TO INCREASE MINORITY STUDENT INTEREST IN RF/MICROWAVE ENGINEERING

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Implementation of Cooperative Learning Techniques to Increase Minority Student Interest in RF/Microwave Engineering:

Abstract

Morgan State University (MSU) is the only Historically Black College and University (HBCU) offering a structured program in RF (radio frequency) and microwaves at the undergraduate level. Within this program, RF/microwave courses are offered as senior electives within the Electrical Engineering curriculum. However, these courses suffered low enrollment, poor retention and minimal student engagement. Recently, with the award of a National Science Foundation (NSF) Course, Curriculum, and Laboratory Improvement Grant, microwave equipment was purchased to provide minority students with a laboratory environment that incorporates cooperative learning to increase student interest in RF Microwave Engineering fields. Studies show that students learn best when they are actively involved in the learning process.[1] Incorporating a hands-on laboratory experience in conjunction with traditional course lecture has been known to actively engage students in learning.[2] However, there has been no documentation to illustrate best practices in implementing cooperative learning techniques to a minority student population in an RF Engineering laboratory environment. This paper will provide an overview of cooperative learning strategies used in the RF microwave engineering laboratory and give an update of the impact of these strategies in increasing minority student interest in the microwave fields. In a pilot study over the period of two semesters, it was shown that through unstructured interviews and pre- and post surveys that student interest in RF Microwave Engineering did increase from 58% to 75% in the Fall 2008 semester and from 30% to 42% in the Fall 2009 semester.

1.0 Introduction

It is widely understood that the need for the U.S. to increase the quantity and quality of its science, technology, engineering and mathematics (STEM) workforce is an issue of national importance and global competitiveness. A white, male and able-bodied population has traditionally dominated engineering. The U.S. Census Bureau estimates historically underrepresented groups will increase half of the workforce by 2050.[3] Given that it is also widely understood that historically underrepresented populations face challenges throughout the educational pipeline often beginning with a performance and resource gap during the critical K-12 years, it become increasingly important to identify effective strategies for engaging this student population.

In fields such as RF/microwave engineering, for which few students have intensive exposure to prior to entering college, the identification of pedagogical strategies, which effectively foster student learning and improve retention is especially desirable.[4] Retention of minorities in RF/microwave fields requires a new approach to student learning. The primary factors in retaining students in engineering-based courses are the students' attitudes toward engineering, self-confidence levels, and the interaction between peers and faculty along with aptitude. Studies show that minority students learn best when they are actively involved in the learning process.[1] Uri Treisman, a mathematics professor at the University of California-

Berkeley, observed that African American students who were failing their courses, studied alone and were reluctant to seek help, but once these students began to work in groups they were able to achieve academic success.[5] Cooperative learning is a well-known method that has been used in the classroom and laboratory to engage students in the active learning process.[5][6][7][8][9] Proper implementation of cooperative learning can improve a student's problem solving skills, individual accountability, and team work – characteristics essential for a good researcher.

Cooperative learning (CL) is instruction that involves students working in teams to accomplish a common goal and must incorporate five basic components: student positive interdependence, individual student accountability, face-to-face interaction, utilization of team-building skill and continuous faculty interaction.[10] Studies have shown that CL in the classroom can result in the following benefits:

- Improve student recall of information[11]
- Improve retention of traditionally underrepresented groups [5][6]
- Improve students engineering skills as it applies to effective communication, teamwork and solving unstructured problems[8][9]
- Improve student attitudes about engineering

Hesketh et. al. proposed a strategy for implementing cooperative learning in a laboratory environment:[12]

- Peak students' interest with a pre-lab handout and have student hypothesize trends for the data which will be collected
- Handout a prelab given to peak the students' interest. Have them hypothesize the trends in the data that will be collected
- Laboratory work should focus on data collection and analysis using only graphical methods.
- Lab discussion should take place in the classroom setting and variable-parameter relationships should be identified during the discussion, which reinforces course lectures on variable-parameter relationships
- Homework assignments should be based upon the data collected in the laboratory

Zemke et al. identifies design features for cooperative learning activities used in an undergraduate engineering laboratory: [13]

- CL activities need to be everyday relevant
- CL activities need to incorporate visual elements
- CL activities need to have working groups
- CL activities need a pre-lab to facilitate student prediction of lab results
- Students need sufficient theoretical background to complete CL activities
- CL activities need clear directions

His findings reflect the responses of a high majority student population and show that the proper implementation of cooperative learning events enabled students to easily master more difficult material. [13] However, there is no evidence of cooperative learning being utilized successfully in a laboratory environment with a student population comprised of a majority of historically underrepresented groups.

Morgan State University (MSU) is the only HBCU offering a structured program in RF (radio frequency) and microwaves at the undergraduate level. The RF/microwave courses are offered as two semester senior electives in the Electrical Engineering curriculum. The first

semester course offered in the fall is *EEGR 443, Introduction to Microwaves*, is the foundational course in microwaves that gives a review of electro-magnetics, transmission line theory, s-parameters and two-port network analysis, and impedance matching. The second semester course offered in the spring is *EEGR 444, Specialized Topics in Microwaves,* builds upon *EEGR 443* and includes topics related to design methodologies on filters and amplifiers. These courses are prerequisites for advanced graduate coursework in RF Microwaves.

Prior to 2008, the Department's microwave courses offered had no laboratory component to complement the theoretical understanding of concepts taught in the course lecture. As a result, students were not actively engaged in the learning process nor motivated to enroll in subsequent microwaves courses. Therefore, because they were not completing the undergraduate courses they were neither eager, nor prepared to pursue graduate study in the field. This paper will describe the methods used to implement cooperative learning activities incorporating unstructured problem solving and design features based upon Zemke's work in a RF Microwave undergraduate laboratory with a high minority student population. In addition, this paper will summarize the impact CL activities had in increasing minority student interest in RF Microwave Engineering.

2.0 Method

This paper reports the findings of a mixed-methods approach to study CL. Data collection took place during two academic semesters: Fall 2008 and Fall 2009. Five instruments were used to collect data and evaluate outcomes: pre-/post- student attitude towards RF Microwave Engineering surveys, a cooperative learning survey, pre-/post- RF Microwave Engineering knowledge and interest surveys, instructor/evaluator observation of cooperative learning survey and a qualitative survey instrument consisting of open-ended questions. For this study, the existing MSU RF/Microwave Engineering senior elective course *EEGR 443 Introduction to Microwaves* served as the target course and incorporated a laboratory component. All students in both course offerings were from historically underrepresented populations. The course instructor is trained as an electrical engineer and has taught the RF/microwave engineering course sequence for 5 years. There were a total of 5 laboratory exercises associated with this senior elective course. Each lab was 2 hours in duration. The experiments were performed in student teams consisting of 3-4 students and monitored by a lab assistant or the instructor. There was a pre-lab prior to each lab activity which required each student to predict the behavior of a microwave component or circuit. Students were allowed to discuss pre-lab individual responses with team members for 10 minutes, after which, a student, chosen randomly from each group by the instructor or assistant was asked to share their response.

2.1 Laboratory Enhancement with Microwave Equipment

In support of this study, a new undergraduate laboratory comprised of state-of-the-art microwave equipment was created. The laboratory has one fully operational test bench as shown in Figure 1. The test bench incorporates a spectrum analyzer (Anritsu @ 7 GHz), a power meter (Anritsu @ 3 GHz), a RF signal generator (Anritsu @ 7GHz) and a combination Vector Network Analyzer/ Noise Figure Meter. Students have been able to

perform calibration and take s-parameter measurements on microwave components using the equipment provided.

Figure 1. Microwave Test Bench Set-up

2.2 Course Enhancement Through Laboratory Experiments

EEGR 443, Introduction to Microwaves focuses on wave types, transmission lines and waveguides, Smith chart, S-parameters, passive components, and measurement techniques. Five laboratory course experiments were created to support theoretical concepts taught in the classroom and all of these incorporated a CL learning event. These concepts are reinforced using the lab exercises on Table 1 below. In addition, these labs give students a basic understanding of the use of the Vector Network Analyzer to study passive component behavior. (i.e. lumped elements, microstrip, and couplers).

2.3 Incorporation of CL Activities in the Laboratory Environment

Each laboratory exercise incorporated CL events that utilized structured problem solving. Structured problem solving is a cooperative learning technique in which the student teams (i.e. teams selected by the instructor) are given a problem to solve based upon theories learned in the lecture. The student teams discuss possible solutions to the problem for a small period of time. At the conclusion of the discussion, the instructor randomly selects one team member who receives no assistance from their peers and responds with a solution to the problem. Referring to Table 2, each lab had the infrastructure based upon work done by Zemke:[13]

Table 1. Description of EEGR 443 Lab Components

Lab Number	Lecture Subject(s)	Lab Concepts and Experiment	Equipment
1	Transmission Line Theory	Learn about Agilent's Advanced Design System (ADS) and how to utilize software to analyze simple microwave circuits.	ADS
2	S-parameters and Network Analysis	Utilize knowledge about s-parameters and create a simple "T" and 'Pi' attenuator circuit. Determine the two-port s-parameter response and the frequency range over which the attenuator meets given specifications.	ADS
3	Calibration	Use the Anritsu's MS4623B Vector Network Analyzer to learn how to calibrate and verify the VNA system's performance.	ADS
4	Planar Couplers	Use Agilent's ADS circuit simulator to simulate, optimize, and layout a Wilkinson and Branchline coupler circuit.	ADS
5	S-parameter Measurement	Use the Anritsu VNA to measure the S-parameters over a range of frequencies for microstrip transmission lines, lumped components (i.e. Resistors, capacitors, and inductors), and the coupler circuit designed in Lab #4.	ADS and VNA

***Table 2. Laboratory* Infrastructure**

Activity	Description	Risk Mitigation
Pre-Lab	A short pre-lab was given to students at the end of a lecture covering a series of topics. The pre-lab provides information that relates to a problem on a subject matter. Each student completed the pre-lab as a homework prior to attending a laboratory session	Instructor verbally gave instructions and answered any questions regarding the pre-lab. Instructor emphasized that the pre-lab was to be completed by each student prior to attending a laboratory session.
Laboratory Session	Each student took 10 minutes to discuss with team members solutions, approaches, and ideas regarding the pre-lab. A recorder summarized all team members' inputs. The recorder from selected groups presented information to the entire class. The last 90 minutes was dedicated to student teams completing the lab exercise.	At the start of the laboratory session, the lab assistant checked to make sure each student completed the pre-lab. Failure of any student to complete pre-lab resulted in a 5% reduction on an individual lab grade. The lab assistant or instructor selected the recorder at this time.
Cooperative Learning Survey	Each student completed and returned a cooperative learning survey immediately following the CL event and prior to starting the lab exercise.	Instructor or lab assistant verbally gave instructions and answered any questions regarding the survey.

2.4 CL Event Design

The cooperative learning event took the form of a pre-lab or a design problem. The course instructor designed three (3) pre-labs and two design problems. A pre-lab or a design problem was given to each student prior to each lab activity. The pre-lab was assigned as a part of a home assignment and required each student to predict the behavior of a microwave component or circuit. In addition, the pre-lab included problems, which encouraged students to utilize new software tools for circuit simulation to verify hand calculations. At the beginning of each laboratory session, students were allowed to discuss pre-lab individual responses with team members for 10 minutes, after which, a student, chosen randomly from each group was asked to share a response. The pre-lab and two additional design problems served as the cooperative learning events. The two additional design problems were created to provide the students a practical 'real world' problem that they could solve using the concepts and theories from class lectures. Figure 2 provides a sample pre-lab and Figure 3 provides a sample design problem.

During the cooperative learning events the instructor, lab assistant, and an evaluator observed student interaction and group dynamics to obtain a qualitative assessment of the impact of CL activities. Figure 4 provides a sample survey used to observe group interaction during a CL activity.

A. Read "Agilent VNA Back to Basics Seminar" pages 40-48 located in Course Materials on Blackboard and answer the following questions.

1. What is the difference between a calibration kit and a calibration standard?
2. Without proper calibration, what type of return loss response can be expected measuring a DUT (ie. device under test)? What causes this type of response?
3. Which errors are removed in One-port error correction? Two port error correction?
4. What is isolation calibration? Should isolation calibration always be performed?

B. **Application example: For the band-pass filter in Figure 1. below answer the following questions:**

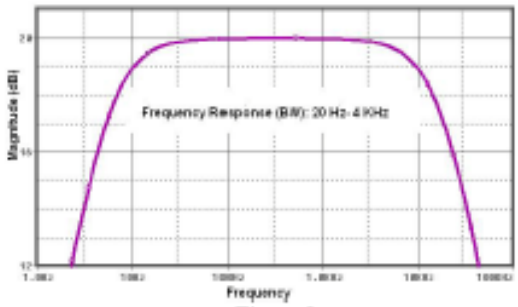

Figure 1.

1. Over what range of frequencies do we need to calibrate the VNA? Explain why.
2. Over what range(s) of frequencies do we get the lowest return loss response? Explain why.
3. Over what range(s) of frequencies do we get the lowest insertion loss response? Explain why.

Figure 2.Sample Pre-lab

Cooperative Learning Activity 1: Coaxial vs. Microstrip

OBJECTIVE:

1) This is an interactive activity.
2) Do not be afraid of making a mistake. Do not be afraid of thinking "outside the box". There is more than one solution to this problem.
3) This is a thinking exercise. Make sure to get input from all group members
4) The recorder will summarize each group members' comments and encourage all group members to participate.
5) The problem is to select a transmission line type (ie. Coaxial or Microstrip) for impedance transformation of a load impedance (ZL) to an input impedance of (Zin) based upon the applications described below.
6) First, read each application. Next, select which transmission line type would be best suited for application described. Thirdly, note requirements for the lowest loss connection using selected transmission line type.
7) Select the materials and identify material properties that would best satisfy requirements for application (implementation). Note any implications (ie. Effects) on size, frequency bandwidth, and loss and visualize connection.
8) Give 3 reasons for your transmission line choice.

Cooperative Learning Activity 1

Application	Select Transmission Line (Microstrip or Coaxial)	Determine requirements for low loss connection	Implications on size, operating frequency, bandwidth, loss	Identify material properties and select materials that satisfy requirements	Visualize connections
1) Low loss connections between the antenna and amplifier in a Blackberry. Maintain 50 Ohm impedances.					
2) Low loss connections between a digital cable box and TV. Impedance transformation from 50Ohms to 75 Ohms					

Figure 3. Sample Design Problem

Directions: For each working group, indicate the proportion (%) of total group members engaged in the following activities:

Name of observer: _____ Date of observation_____ Lab # _____

	Group Number					
Cooperative Learning Activity	I	II	III	IV	V	VI
1. Exchanging ideas						
2. Explaining concepts						
3. Taking notes						
4. Listening						
5. Asking questions						
6. Resolving conflict						
7. Encouraging others						
8. Helping others with equipment						
9. Arriving to class on time						
10. Working until the task is done						
11. Creating a plan						
12. Assuming a particular task						
13. Applying an algorithm/calculation						
14. Summarizing/recording						
15. Researching						

Figure 4. Observation of Cooperative Learning Survey

3.0 Cooperative Learning Strategy Outcomes

Five instruments were used to collect data and evaluate student cooperative learning outcomes: pre-/post- student attitude towards RF Microwave Engineering surveys, a cooperative learning survey, pre-/post- RF Microwave Engineering knowledge and interest surveys, instructor/evaluator observation of cooperative learning survey and a qualitative survey instrument consisting of open-ended questions. The survey findings provided insight on best strategies for incorporating CL activities with a high minority student population and supported prior findings by Zemke that CL activities when utilized properly, can engage students in learning.

3.1 Fall 2008 Survey Results

During the Fall 2008 semester, 12 students were enrolled in *EEGR 443 Introduction to Microwaves* and all students agreed to participate in the study and returned surveys. The course participant demographics consisted of 38% females and 63% males. Data for race was not reported to maintain anonymity of the individuals in this small student population (ie. < 15).The results shown in Table 3 for the Fall 2008 cohort show that in-class examples and CL events held the students' attention and were the easiest to master. The students noted on the qualitative surveys in response to, "What part of the cooperative learning activities did you enjoy?", the majority of the responses can be summarized that the students enjoyed working with their team members and that they were able to obtain different views or approaches to solving a problem. This supported the results from observations made by the instructor and evaluator where 75% - 100% of the students in a group were actively engaged and did explain ideas and concepts with each other during each CL activity. The surveys also showed that the motivation for students to pursue graduate study increased from 58% to 75% and to

pursue a career in RF Microwave Engineering increased by 58% to 75% by the end of the Fall 2008 semester.

Table 3. Summary of Cooperative Learning Survey for Fall 2008

Preferred Teaching Method	Challenge To Think Most Deeply	Spark The Most Curiosity	Hold Attention	Easiest to Master
Lecture	1	1	1	1
Reading	2	2	0	0
CL Event	**0**	**1**	**2**	**2**
HW Problems	1	0	0	0
In-Class Examples	1	1	2	2

3.2 Fall 2009 Survey Results

During the Fall 2009 semester, 17 students were enrolled in *EEGR 443 Introduction to Microwaves* and all students agreed to participate in the study and returned surveys. The course participant demographics consisted of 24% females and 76% males. The majority of the course's participants were of African descent including students who self-identified as African American, African or Guyanese-American. The results in Table 4 for the Fall 2009 cohort show that CL events was the preferred teaching method which sparked the most curiosity about wanting to learn about RF/microwave engineering. Consistent with 2008 results, to the question, " What part of the cooperative learning activities did you enjoy?", the majority of the responses indicate that the students enjoyed working with their team members and that they were able to obtain different views or approaches to solving a problem. A qualitative survey instrument consisting of open-ended questions was conducted as a focus group at mid-semester and as a pen and paper instrument at the end of the semester. Students noted during the focus group that having a better understanding of the prerequisite Electromagnetics course improves a student's performance in the EEGR 443 course as well. The surveys also showed that the motivation for students to pursue graduate study increased from 12% to 34% and to pursue a career in RF Microwave Engineering increased by 30% to 42% by the end of the Fall 2009 semester.

Table 4. ***Summary of Cooperative Learning Survey for Fall 2009***

Preferred Teaching Method	Challenge To Think Most Deeply	Spark The Most Curiosity	Hold Attention	Easiest to Master
Lecture	1	2	5	2
Reading	2	2	1	1
CL Event	**5**	**7**	**3**	**3**
HW Problems	7	1	5	3
In-Class Examples	2	5	3	8

3.3 Summary

A cohort comprised of students enrolled in Fall 2008 and Fall 2009 offerings of the undergraduate course, *EEGR 443 Introduction to Microwaves*, was used to investigate the impact of cooperative learning techniques upon minority student interest in RF Microwave Engineering fields. It was shown that cooperative learning is an effective strategy to actively engage students in the learning process and that interest in RF Microwave Engineering did increase by the end of each semester. Although the surveys provided some quantitative support, the author feels that the qualitative responses from each cohort provides a better illustration of the impact of cooperative learning in an undergraduate laboratory setting with a high population of students from historically underrepresented groups. The following four themes emerged from the qualitative responses in support of CL events:

1. ***Improved peer interaction and learning:*** The surveys showed that the students enjoyed the peer interaction and discussions. The following comments were made on the qualitative surveys:

   " I enjoyed working with my partners because we were able to try to solve the problem from different approaches."

   " The exchange of ideas and it helps one to express an idea."

   "Being able to express to my classmates what I learned, or my approach to a problem."
2. ***Improved student experience in discussing difficult concepts***: As a result of the student interaction, students were able to discuss difficult concepts with their peers without the fear of rejection. Students were more open to explore different solutions to problems. The following comments were made on the qualitative surveys:

   "The question/answer session, which really made the group's leader (speaker) pick his/her brain. And this also made the other group members to understand concepts not previously understood."

   "I enjoyed the collaboration between group members. If I did not understand a concept I would ask a group member who did and they explained it to a level I could understand."
3. ***Increase in student confidence***: As the saying goes, "you know a subject well when you are able to teach it to another." Students were able to share their knowledge and explain concepts to each other.

   "To me, it is an awesome activity. Sometimes we (students) are the ones that understand each other and our language! We explain better if we understand its concept."
4. ***Student knowledge gaps decreased***: Students were able share and obtain new information from others. The cooperative learning activity reinforced theoretical concepts and provided the instructor opportunities to use visual elements to explain more

difficult concepts. Through discussions, a student would be able to obtain information he/she would have missed in the classroom.

" The discussions were helpful in understanding the course."

"I enjoyed the interactive learning among my peers. I was able to see how other people think and the methods they used to answer the question. I was able to either re-enforce what I learned by sharing it with others and concepts became clearer when they were explained by peer members."

To further improve the impact of cooperative learning on students from historically underrepresented groups, this author suggests that students have some knowledge, prior preparation and interest in RF microwave engineering. RF/microwave instruction draws heavily upon highly abstract concepts, many of which lack immediate relevance to students. Participation in undergraduate research experiences, enrollment in electromagnetic courses, and exposure to technical conferences that relate to RF microwave topics or involve RF microwave engineers were reported sources of prior knowledge. Student exposure to these types of experiences and learning opportunities serve as important foundational knowledge which possibly increases the likelihood of concept mastery, retention and ultimately socialize important skills and qualities important for an RF engineer. This study demonstrates that the successful application of CL in instructing undergraduates in RF/microwave engineering suggests that CL can be successful in the instruction of more abstract concepts and further enhance the instruction of more relevant concepts.

Bibliography

[1] Williams, Larry De Van. "Educating Minority Children in an Environment that Makes Engineering Education an Attainable Goal." *IEEE Communications Magazine* (December 1990): 58-60.

[2] McIntosh, R. E., "A modern undergraduate microwave engineering laboratory," *IEEE Transactions in Education* (August 1970): pp. 110-114.

[3] Toossi, Mitra, "A century of change: the U.S. labor force, 1950 -2050 ," Office of Occupational Statistics and Employment Projections, Bureau of Labor Statistics, May 2002, Vol. 125, No. 5.

[4] May, G. S., Chubin, D. E., "A Retrospective on Undergraduate Engineering Success for Underrepresented Minority Students," Journal of Engineering Education, January 2003.

[5] Treisman, U., "Studying Students Studying Calculus: A Look at the lives of minority mathematics students in college", *The College Mathematics Journal*, Vol. 23, o. 5, pp. 362-372.

[6] Bonsangue, M., "An efficacy study of the calculus workshop model," *CBMS Issues in Collegiate Mathematics Education,* Vol. 4, American Mathematical Society, Providence, RI, 1994. pp. 117-137.

[7] Prince, M., "Does Active Learning Work? A Review of the Research." *Journal of Engineering Education*,Vol. 93. No. 3, July 2004, pp. 1-9.

[8] Terenzini, P. T., Cabrera, A. F., Colbeck, C. L., Parente, J.M., and Bjoklund, S. A., "Collaborative Learning vs. Lecture/Discussion: Students' reported learning gains." *Journal of Engineering Education*, Vol. 90, No. 1, pp. 123-130.

[9] Felder, R. M., Felder, G. N., and Dietz, E. J., "A longitudinal study of engineering student performance and retention, vs. Comparsions with traditionally-taught students," *Journal of Engineering Education*, Vol. 98, No. 4, October 1998, pp. 469-480.

[10] Johnson, D.W., R.T. Johnson and K.A. Smith, "Cooperative Learning: Increasing College Faculty Instructional Productivity," *ASHE-ERIC Higher Education Report No. 4*, George Washington University, 1991.

[11] Berry, Carlotta, "The Re-Design of an Introductory Circuits Course Based Upon Student Demographics," *Proceedings 2005*. ASEE/IEEE Frontiers in Education Conference.

[12] Hesketh, R. P., Farrell, S., & Slater, C. S., "An Inductive Approach to Teaching Courses in Engineering," *Proceedings 2003.* American Society for Engineering Education Annual Conference & Exposition.

[13] Zemke, S., Elger, D., Beller, J., "Tailoring Cooperative Learning Events for Engineering Classes," *Proceedings 2004*. American Society for Engineering Education Annual Conference and Exposition.