2006-323: THE FORMATION OF COOPERATIVE LEARNING TEAMS BASED UPON STUDENT DEMOGRAPHICS

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The formation of cooperative learning teams based upon student demographics

Abstract

This paper examines the methodology used to form cooperative learning teams for an introductory circuits course. In the 2004 school year, the engineering undergraduate population at Tennessee State University was 88 % African American and 26 % female. This demographic distribution presents some interesting research questions. How does cooperative learning team formation and composition change when the teams are at a minority serving institution? Should the team composition still include at least two women or "traditional" minorities in order to insure overall team effectiveness? Who would be considered a minority with respect to the cooperative learning team composition? A statistical analysis using SPSS was used to determine if there was any statistical difference in individual and team performance based upon team composition with respect to pre-requisite grade, gender, race, learning style and various other factors. In this presentation, the analysis of team performance indicated that there was no significant difference in individual student exam grades but there was a difference with respect to team assignments and the final course grade.

Introduction

Tennessee State University is a historically African American university in Nashville, TN with an approximate enrollment of 10,000 students. The College of Engineering, Technology and Computer Science has an approximate enrollment of 1,000 students and dc circuit analysis is required by all engineering majors. In 2004, the engineering undergraduate population in the college was approximately 88 % African American and 26 % female. The high percentage of female enrollment may be based upon current trends that indicate a decrease in the enrollment of African American males in college. The dc circuit analysis course is taught using active learning activities such as cooperative learning teams. Some of the research questions to be answered by this paper include: How does cooperative learning team formation and composition change when the teams are at a minority serving institution? Should the team composition still include at least two women or "traditional" minorities in order to insure overall team effectiveness? Who would be considered a minority with respect to the cooperative learning team composition?

The dc circuit analysis course is required by all engineering majors including electrical, mechanical, architectural, and civil. Previous research indicates that teams formed by self-selection may not be as effective as those formed by the instructor. This previous work indicates that heterogeneous team composition by grade and interest is more effective with respect to student performance, attitude and efficiency[1,2]. With regards to these results and previous work on the statistical analysis of student performance in this course based upon demographics, a methodology for team formation was created[3]. This methodology included student self-assessments and concept inventories based upon Eric Mazur's work, the Felder-Solomon index of learning styles as well as a consideration of gender, race, and pre-requisite grades[4,5]. The pre-requisites for this course are Physics II, Calculus IV and programming. The basic content of this course includes Ohm's Law, Kirchoff's voltage and current laws, mesh and nodal analysis, Thevenin's and Norton's theorems, first-order and second-order circuits and operational amplifiers.

The circuits course cooperative learning teams were required to work together the entire semester to solve in-class concept questions and circuit analysis problems. The teams were also required to meet outside of class for a minimum of one hour per week to study for quizzes and exams and to complete their homework. Additionally, the teams were required to complete three computer projects during the semester. In order to monitor student performance and progress, all teams were required to submit a team charter, meeting minutes and peer evaluations. The teams all received a lecture on the Tuckman stages of team formation and the five cooperative tenets. The students also completed five progress memorandums for the final computer project based upon the Woods problem solving technique. There was also a course website that served as a central repository for all of the course and teaming materials.

This work will present the process of cooperative learning team formation at a minority serving institution, the tools used to place students in teams and team performance. This paper will present team composition based upon demographics and the aforementioned criteria. This document will also attempt to address the research questions based upon team performance based upon composition. The primary motivation for this work is to increase the retention of minorities and women in engineering by incorporating active learning into the classroom environment. In order to achieve this goal, it is necessary to understand what techniques actually influence the performance of underrepresented populations in engineering. Additionally, a byproduct of this effort would be to teach the student some valuable teamwork skills that they will need as an entry level engineer. For the remainder of this document, "traditional" minority refers to underrepresented populations in engineering such as females or African Americans. Thus, the term minority will refer to students who would be considered a minority at TSU such as Asian, Caucasian, Hispanic or American Indian.

Methods of Evaluation

The methods used for team formation in the dc circuit analysis course involved the following process. On the first day of class the instructor and all of the students introduced themselves in a one minute presentation. Then the course syllabus, team assignments, individual assignments and student expectations were reviewed. The entire class then went to the computer laboratory and the students were introduced to all of the content available on the course website. This content included lecture notes, concept tests, team documents, online forms and assignments. The students then completed three online forms which served as their first three homework grades. The grade on these assignments was either a 100 for completing it or a '0' so that they would not feel obligated to provide any certain response. The first form was a concept inventory that covers basic pre-requisite knowledge [see Appendix A]. The second form was the Felder-Solomon index of learning styles available at the North Carolina State University website[5]. The final form was a student self-assessment based upon Mazur's work which includes a series of questions based upon the student's pre-requisite courses and classroom experiences[4]. The student self-assessment is shown in Appendix B. During the first week of school, the instructor used the responses to all of these documents as well as the students' pre-requisite grades, classification, race and gender to put them into teams of four to five persons. The teams were designed to be representative of a diversity of skill sets. Therefore, a team may have one student skilled in programming, one in Calculus and one in Physics. The teams were also designed to include a diversity of majors. The team also had a diversity of learning styles and possibly two or more women or minorities (Caucasian, Asian, Hispanic). By the second week of class the students were placed in their cooperative learning team. During the class when the team compositions were presented, there was a discussion of the Tuckman stages of team formation, the five cooperative tenets and the Woods Problem Solving methodology. The students were then informed that they should use these techniques to create a team contract and memorandums to work through their assigned projects. The students were informed that they must meet for a minimum of one hour per week and during the first meeting they should create the team contract/charter that includes a team name, goal, member expectations and conflict resolution techniques. The students were expected to continue to meet weekly for the remainder of the 14 week semester in order to complete 3 semester long projects. Two of the projects were completed in PSpice and one of them was a computer programming design project due on the last day of class. The students were also informed that they were not allowed to work on the projects individually and that they could not change teams once assigned.

Results

For the purpose of this study, there were sixty-three (63) students over three semesters placed in seventeen (17) cooperative learning teams. It should be noted that due to student attrition, this teams included some students from prior semesters. The goal was to have four members per team but based upon course enrollment and student attrition at times there were teams of three or five members. The learning styles for the students covered the full range including active and reflective, sensing and intuitive, visual and verbal, and sequential and global. The concept inventory scores ranged from 20% to 90% and were an average of 56%. The pre-requisite grades in Calculus IV, Physics II and the programming course also ranged from C to A.

Since Fall 2004, this method of team formation has been used extensively for five different sections of this course. Of these five sections, the author taught four of them. In this period, there have only been two teams that have been allowed to change members after the initial formation. These changes were approved based upon schedule conflicts, i.e. team members in the marching band practiced every evening after school and traveled most weekends and attrition led to a team of two. This dilemma was resolved by placing the 4 band members on the same team which gave them opportunities to meet on the weekend and on the bus traveling to football games and merging the two students into other teams. It should be noted that the reorganization based upon the band member conflict created two teams with one female. Traditionally, a minimum of two women or minorities were placed on a team to eliminate any feelings of isolation or intimidation. Additionally, there have only been minimal requests to change teams after the initial formation and none of these were granted. All students were expected to work out their conflicts per their team contract as they will be required to do in the workplace. One key issue encountered was student attrition, which caused some teams of four to be reduced to two by the end of semester. Another confounding issue was that many students had part time employment and scheduling was a huge problem. The students were informed that this process would prepare them for the real world therefore they should determine a method to resolve all conflicts and logistical problems.

This study included 23 males (37%) and 40 females (63%). The racial breakdown of these students was 55 African American (87%), 6 white (10%), and 2 Asian (3%). Figures 1 and 2 present the demographic distribution of these students in these courses by major and classification. Note that in Figure 2, the CISE and ENGR majors are masters degree (MS) students. Also in Figure 2, the engineering majors are architectural (AREN), mechanical (MEEN), civil (CEEN) and electrical (ELEN) engineering.

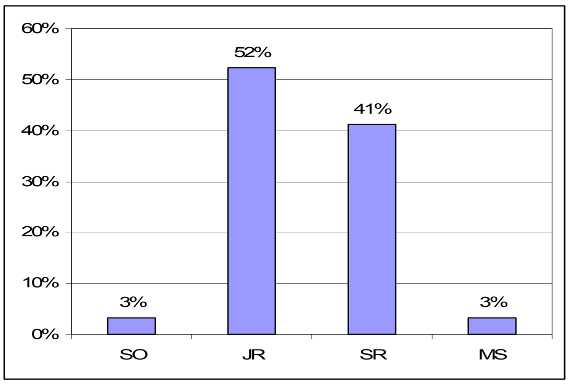


Figure 1. Course Major Distribution

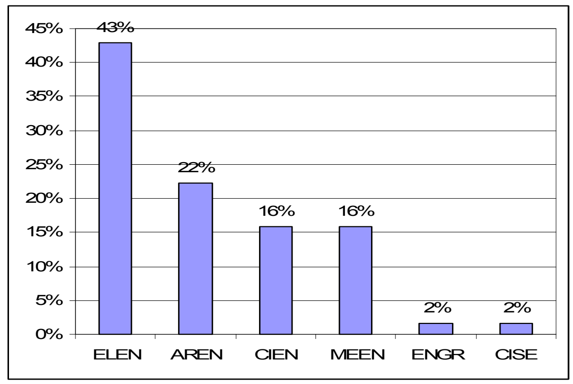


Figure 2. Course Classification Distribution

The remainder of this section will present the team composition based upon student learning styles, performance on the concept inventory, student self-assessment responses and pre-requisite grades.

Index of Learning Styles

The Felder-Solomon Index of learning styles has four basic categories: active-reflective, sensing-intuitive, visual-verbal, sequential-global. This index will indicate that a student has a moderate to strong preference towards one of the learning styles but it does not indicate that the student can only learn by being taught to that particular style[5]. This index may be used to inform the instructor about techniques for tailoring information presentation to the learning styles of the class but not to label individual students[5]. The sensing style (Se) indicates that students may have a preference for concrete thinking or the practical aspects of concepts. The intuitive learner (In) has a preference for abstract concepts. The visual learner (Vi) prefers to be taught with diagrams or visual representations. The verbal (Vr) learner prefers a written or spoken explanation when learning concepts. An active learner (Ac) prefers to learn by trying things out or working in groups. A reflective learner (Re) likes to learn by thinking things through. A sequential learner (Se) is a linear thinker preferring to learn in small incremental steps. A global learner (Gl) may prefer holistic thinking and likes to learn in large leaps. The active/reflexive dimension of this model has a parallel with the Kolb learning style model. The active/reflective dimension of this model has a parallel to the extrovert and introvert type of the Myers-Briggs type indicator. The four categories of the index of learning styles show that there are sixteen possible learning style indicators. There was at least one student who fell in each of these categories except for the following three: Reflective, Intuitive, Visual, Global (ReInViGl), Reflective, Intuitive, Verbal, Global (ReInVrGl), and Reflective, Sequential, Verbal, Global (ReSeVrGl). Table 1 presents the number of students in the course that fell into each category. The table is not representative of the entire set of data because there are some students who did not complete the inventory.

Table 1. Student Learning Styles

		Verbal		Visual	
		Sequential	Global	Sequential	Global
Reflective	Sensing	4 (7%)	0 (0%)	9 (16%)	1 (2%)
	Intuitive	2 (3%)	0 (0%)	3 (5%)	0 (0%)
Active	Sensing	3 (5%)	1 (2%)	21 (36%)	4 (7%)
	Intuitive	1 (2%)	1 (2%)	7 (12%)	1 (2%)

Concept Inventory

The concept inventory shown in Appendix A evaluates the students' mastery of key concepts from the Physics II pre-requisite. These concepts include Ohm's Law, parallel and series resistors, Kirchoff's current and voltage law, and the law of conservation of energy. It is expected that a student with a minimum of a C in the pre-requisite course would be able to answer at least 6 out of 10 questions correctly. The mean score on the concept inventory was found to be 5.07.

Student Self-Assessment

The student self assessment was used to determine student attitudes about classroom instruction, course preparation, teams and personal interests. This section will provide a sampling of some of the responses that were used to place students in cooperative learning teams. Table 2 shows some of the qualitative data that was collected during the team formation process.

Table 2. Student Self Assessment Reponses

Question	Response
2c	My favorite teacher was Ms ____ my 2nd grade teacher. What I like about her was she was a teacher but also a friend and if me and my boy ever had problem we knew we could talk to her. She always let us do what me and my boy wanted as long as we got her agenda done first. The only thing I can say is we only learned what she wanted us to learn although we had plenty of time to have extend learning period, but instead we went to hang with our 8th grade brother. What I mean by that is we'll do all our work by lunch and after lunch we leave class with instructor's permission to go sit in the class with our brothers. The only thing we miss is lunch because all our work was done. So the most enjoyable thing I like about her was our relationship.
2c	The thing I learned the most was you have to open and honest while working within a group and that the communication within the group must be consistent in order to accomplish you goals. The thing that I learned the least was extra tips about going

	to interviews.
2c	I learned that you can do anything as long as you work for it and that it is okay to ask questions no matter how dumb they might sound to anyone else. Situations that enable me to learn the best is when the professor is willing to take the time to explain the information.
3d	The favorite part of a class that I really enjoyed was doing experiments and predicting the hypothesis.
3e	My least favorite part about a class that I did not enjoy was when the teacher talked; he talked like he didn't even want to be teaching the class.
4a	Okay as long as I don't end up doing all the work, and am not penalized for performance of other team members.
4b	It depends on the subject. Sometimes a peer may be able to explain something in a way that I can better understand.
4c	I tend to stand back and listen to others to much rather than add my input when working on a team, which prevents me from learning when working with a team.
4d	1. Well-designed teams are extremely productive. 2. Teams designed no so well often impede learning.
4d	It enables you to get another persons understanding of the material and help someone else out that may be struggling.
4e	He/She is able to simplify difficult concepts, and present it in interesting way.
4e	He knew the material well and could easily put in terms understandable by someone who had never been exposed to the material before, and made the students feel comfortable about asking questions.

Team Composition

The team composition based upon prerequisite grades indicated that the mean grade point on Physics II, Calculus IV and programming for most teams was between a C+ and B-. With respect to the major composition, all of the teams had an electrical engineer except for 3. Additionally, there were only two teams that had graduate students on them. There was only one team that had a representative from each major and 50% of the teams had an architectural, civil, or mechanical engineer. There were four all male teams, four teams with one female and 3 males, five teams with half women and half men, and four teams with one male. There were twelve teams that were all African-American, two teams with one Caucasian student and two teams with one Asian student. There was only one team that with all Caucasian students. Due to some courses only containing one minority student it was not possible to put a minimum of two per team. All of the teams included at least one active learner however three teams did not have a reflective learner. All the teams had a sensing learner however eight teams did not have an intuitive learner. All the teams had visual learners however eight teams did not have a verbal learner. Finally, all the teams had sequential learners but ten did not have a global learner. It should be noted that all data was not available for all students on all teams which may account for some discrepancies.

Statistical Analysis

In order to evaluate team effectiveness based upon composition, data was collected from the team members such as team project grades, individual assignment grades, and exam grades. The student data was then categorized based upon team membership. SPSS was used to determine if there was any statistical difference in individual and/or team performance based upon team composition. It should be noted that a significance of 10% indicated a trend for a certain composition while a significance of 5% indicated that this composition had a significant negative or positive effect on student performance based upon grades. Due to the small sample size and the distribution of the data not being normal, the Mann-Whitney U Test and Kruskal-Wallis U Test were used. There was no significant difference found between exam grades based upon team composition. However, there does appear to be a statistical difference at a level of 5% for the team projects and the individual final course grade. It should be noted that the team projects are 20% of the final course grade and therefore the project grade influences that variable. Based upon that fact, the remainder of this section will only address project grades based upon team composition.

Tables 3 and 4 present the data for the top 3 and bottom 3 teams, respectively. The data was determined by finding the mean grade for all three projects for all teams and sorting it from highest to lowest. The purpose of this tabulation was to determine any identifiable differences between the two sets of teams. Both sets of data had a team of all African American and all male teams. There was no key difference in the pre-requisite grades or the majors between the groups. The only difference appeared to be in the learning styles and the bottom teams seemed to have less diversity with respect to the preferred learning style.

Table 3. Top 3 Teams

Team	**Race**	**Gender**	**Learning Style**	**Major**	**Pre-requisite grades**
I	3 Caucasian	3 Male	AcInViGl AcSeVrSe ReSeVrSe	2 electrical 1 mechanical	Calc 3.33 Phys 2.33 Prog 2.67
N	2 African American 1 Asian	2 Female 1 Male	AcInViSe AcSeViSe AcSeViSe	1 architectural 2 electrical	Calc 3.33 Phys 2.67 Prog 3.00
O	4 African American	1 Female 3 Male	AcSeViSe ReSeViSe ReSeViSe	3 architectural 1 civil	Calc 3.00 Phys 2.75 Prog 3.00

Table 4. Bottom 3 Teams

Team	Race	Gender	Learning Style	Major	Pre-requisite grades
C	3 African American	3 Male	***********	2 electrical 1 masters	Calc 4.00 Phys 2.50 Prog 3.00
H	3 African American 1 Asian	1 Female 3 Male	AcSeViSe AcSeViSe ReSeViSe ReSeVrSe	1 architectural 1 civil 2 electrical	Calc 2.75 Phys 2.25 Prog 3.25
M	4 African American	4 Male	AcSeViSe AcSeViSe AcSeViSe AcSeViSe	1 architectural 1 civil 1 electrical 1 mechanical	Calc 2.75 Phys 3.50 Prog 2.50

Conclusions

This paper has been presented a survey of the instruments used for team formation and student performance based upon team composition in an introductory circuits course. These instruments included the Felder-Solomon index of learning styles, student self assessment and concept inventories. Other criteria used for the team formation included student preference, race, gender and pre-requisite grades. The methodology presented here has proven to be an effective procedure for placing students in teams with minimal conflict. The statistical analysis indicated that although individual exam grades were not affected by the team composition, the final course grade and team assignments were. Although, there was a statistical difference in the team project grades, it was not immediately apparent what factor influenced the difference in performance. This result indicates a need for a more rigorous analysis with a larger data set and possibly over more variables.

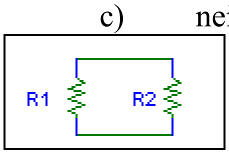
With respect to the research questions, How does cooperative learning team formation and composition change when the teams are at a minority serving institution? Should the team composition still include at least two women or minorities in order to insure overall team effectiveness? Who would be considered a minority with respect to the cooperative learning team composition? Tables 3 and 4 indicate that it may not be necessary to have a minimum of two minorities and two females in order to insure team effectiveness. This conclusion was reached based upon the fact that there are teams in the top and bottom of the course without this composition. The minority in this context applies to the Asian and Caucasian students however it did not appear to negatively or positively affect team performance. Therefore, at a minority serving institution it may not be necessary to always include more than one female per team or more than one nontraditional minority per team.

Appendix A Concept Inventory

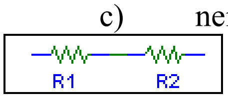
Name: ______________________________________

Please select the answer to each of the following questions. The responses to this concept inventory will not negatively affect your course grade.

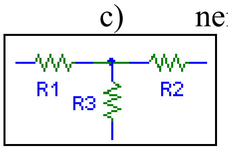
1. If the current through a resistor is increased, then the voltage across the resistor will
   a) increase
   b) decrease
   c) remain the same
   d) none of the above
2. Current is the rate change of
   a) charge
   b) energy
   c) power
   d) none of the above
3. A short-circuit (wire) has a resistance of
   a) 10kΩ
   b) 0Ω
   c) undefined
   d) none of the above
4. An open circuit has a current of
   a) 15 mA
   b) undefined
   c) 0A
   d) none of the above
5. In the following network, R1 and R2 are in
   a) series
   b) parallel
   c) neither



6. In the following network, R1 and R2 are in
   a) series
   b) parallel
   c) neither



7. In the following network, R1 and R2 are in
   a) series
   b) parallel
   c) neither



8. If resistors are in parallel, they have the same
   a) voltage
   b) current

c) voltage and current
d) power

9. If resistors are in series, they have the same
   a) voltage
   b) current
   c) voltage and current
   d) power
10. Kirchhoff's current law (KCL) states that
   a) energy can be neither created nor destroyed only transferred
   b) the sum of the voltages around a loop is zero
   c) the sum of the currents in and out of a node is zero

On a scale of 1 to 10, with 10 being excellent, how do you think you did on this inventory and comment on why

1 2 3 4 5 6 7 8 9 10

Comments:

Appendix B Student Self Assessment

Name: ______________________ Date: ______________________
Gender: ______________________ Race: ______________________

Please read and answer each of the following statements. The responses on the self assessment will not negatively affect your course grade.

1. Personal Interests
   1a. What are your interests?
   1b. What are your expectations after you graduate?
   1c. What do you want to be doing 5 years after you graduate?
2. Instruction:
   2a. Explain your typical interaction with your teachers/professors.
   2b. What are your expectations of your teachers/professors?
   2c. Think about the best teacher you ever had. What did you learn the most? What did you learn the least? Explain the situation that enables you to learn the most and least?
3. Courses:
   3a. What have you heard about this course?
   3b. What do you hope to learn in this course?
   3c. What do you expect the lectures to do for you?
   3d. Think about a class that you really enjoyed, what was your favorite part of the class?
   3e. Think about a class that you did not enjoy, what was your least favorite part of the class?
   3f. Name one specific thing you remember from Physics class.
   3g. Name one specific thing you learned in Calculus class
   3h. Name one specific thing you learned in programming class.

3i. How many hours per week do you think it will take to learn all you need to know from this course? Include everything: lectures, homework, group meetings, etc.

4. Teams:
    - 4a. How do you feel about working on teams?
    - 4b. Do you learn better by yourself or in a team?
    - 4c. Explain what prevents you from learning by yourself or in a team?
    - 4d. Explain what enables you to learn by yourself or in a team?
    - 4e. Think about the best teacher you ever had. What made him or her a good teacher?
    - 4f. Think about the worst teacher you ever had. What made him or her a bad teacher?
    - 4g. Name one person in this class you would like to be on a team with. (Note: you do not have to provide a reason and no one else will see this assessment)
    - 4h. Name one person in this class you would not like to be on a team with. (Note: you do not have to provide a reason and no one else will see this assessment)

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