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# Assigning Students to Groups for Engineering Design Projects: A Comparison of Five Methods

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## I. INTRODUCTION

The fact that group learning can enhance education is well established. No less an authority than Albert Einstein<sup>1</sup> argues persuasively for the essentially collaborative nature of human learning. Likewise, Harold Leavitt suggests that all organizations must consider the influence of informal groups on critical processes:

“The problem is not shall groups exist, but shall groups be planned or not? If not, the individualized organizational garden will sprout groupy weeds all over the place.”

More recently, researchers such as Bruffee<sup>3</sup>, and Johnson and Johnson<sup>4</sup> have explored the positive contributions groups can make to education in much greater detail. Porter<sup>5</sup> asserts that to be its best, education must become a team sport. The Harvard Assessment Seminars found particularly strong support for the use of groups in higher education.<sup>6</sup>

How group assignments should be made to optimize student learning is far from clear. Numerous methods of group assignments can be used, ranging from allowing the students to select their own groups to the instructor making the group assignments using a variety of different criteria. This paper presents the results of an investigation into the effectiveness of group performance using five different methods of assigning students to work groups. The investigation took place at the United States Air Force Academy during the Fall semester 1991, and involved a core course taught by the Academy's Department of Civil Engineering, CE 310, “Air Base Design and Performance.”

In Civil Engineering 310 students work on course projects in groups. Before this study, there were no standards for assigning students to these groups; it was left to each individual instructor's discretion, wondering if certain methods of selecting groups might be more effective than others.

## II. COURSE BACKGROUND

CE 310 is a core curriculum requirement for all junior-level cadets at the Academy. The course was designed to progress

from a low Perry-level\* to a relatively high Perry-level emphasizing team work, communication (oral and written), and basic comprehensive planning tools for the design of Air Bases for the Air Force.

The course is divided into three distinct blocks: (1) The framework for designing much of the base infrastructure...runway, taxiway and apron/pad designs, rigid and flexible pavement designs, as well as utility systems requirements, (2) Base Comprehensive Planning (BCP) and related socio-political and environmental concerns...noise, Air Installation Compatible Use Zones (AICUZ), and encroachment, and (3) air base performance in a combat environment...force bed-down, pre-attack planning, and base recovery after attack. Each block culminates in a group project requiring the students' synthesis of all the material covered in that block. The course also has quizzes and examinations in order to test the students' subject knowledge. Overall, 44% of a student's final grade was based on group effort and 56% on individual effort.

For the Fall, 1991 semester, there were 442 students enrolled in 24 sections of CE 310. Within each section students were divided into work groups of approximately four students. Each section had a maximum of 20 students. The course was taught by eight instructors.

## III. EXPERIMENTAL DESIGN

Our intention was to test whether grouping students according to ability (as indicated by their incoming GPAs) or curricular interests (technical or nontechnical) affected student performance, attitudes, or efficiencies when compared with allowing students to select their own groups. Each class, or section, was first grouped by interest: the “technical” group were those students majoring in engineering or the basic sciences, and the “nontechnical” group were those students majoring in humanities or the social sciences. A third group was identified, neither technical nor nontechnical, that consisted of students who were meeting the minimum graduation requirements. This group (Bachelor of Science, BS) would fill a technical or nontechnical position based on the specific needs of a section to completely fill all groups. After the class was separated by interest, the individuals were then rank-ordered by GPA. The desired number of students in each group was four. In most cases, each group had four students assigned, however, for classes with less than 20 students, some three-person teams were created.

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\*For a complete discussion of Perry Level, see: Culver, R.S. and J.T. Hackes. *Perry's Model of Intellectual Development*. Engineering Education: 221-226 (December 1982)

The five methods of group assignments are illustrated in Table 1. Method 1 involves assigning groups heterogeneously/heterogeneously with respect to GPA and Interest, i.e., each group has both technical and nontechnical majors, and the GPAs of all group members are different. Those groups assigned by method 2 (heterogeneous/homogeneous) are comprised of only technical or nontechnical majors and the GPAs of all group members differ. For method 3 (homogeneous/heterogeneous), each group again has both technical and nontechnical majors, but their GPAs are all similar. Method 4 (homogeneous/homogeneous) has groups assigned with either all technical or all nontechnical majors, and all group members have similar GPAs. Method 5 was the control; students selected their own teams.

All groups within a particular section were assigned using the same method. The methods varied among sections. There

Type of Group	
Method 1	Heterogeneous GPA Heterogeneous Interest
Method 2	Heterogeneous GPA Homogeneous Interest
Method 3	Homogeneous GPA Heterogeneous Interest
Method 4	Homogeneous GPA Homogeneous Interest
Method 5	Self-Select

*Table 1. Methods of Group Assignments*

Critique Questions Used for Analysis									
0	1	2	3	4	5	6	7	8	9
Strongly Disagree		Disagree		No Opinion		Agree		Strongly Agree	
				Neutral					
CRITERIA:									
1. I would like to take more classes from instructors who teach like this one.									
2. My instructor provides a positive image of a military professional.									
3. This course stimulated me to think about the material outside of class.									
4. This course helped me take responsibility for my own learning.									
5. I believe this course will be relevant to my future.									
6. I expect my grade to reflect my proficiency accurately.									
7. I worked harder in this course than I had expected.									
INSTRUCTOR:									
1. My instructor helped make this course more enjoyable.									
2. My instructor helped me to think more critically about the material.									
3. My instructor helped increase my knowledge of the subject.									
PROJECTS:									
1. Assigned projects, exercises and labs were enjoyable.									
2. Projects, exercises and labs helped me think more deeply about the material.									
3. Projects, exercises and labs increased my knowledge of the subject.									
CLASSMATES:									
1. My classmates contributed to my enjoyment of the course.									
2. My classmates helped me think more deeply about the material.									
3. My classmates helped me increase my subject knowledge.									
COURSE:									
1. Overall, this course was enjoyable.									
2. This course helped me develop my thinking skills.									
3. This course has increased my knowledge of the subject.									

*Table 2. Course Critique*

were five sections for each method of assignment except for method 1 (heterogeneous/heterogeneous) which only had four. The five groups in each class or section were named Eagle (E), Falcon (F), Ice (I), Maverick (M), and Yankee (Y), and the groups were selected such that each group had similar average GPAs.

The instructors were informed that an experiment was under way; however, they were not informed as to how each of their section's groups were selected. Instructors teaching multiple sections were likely to have different grouping strategies used in each section. The students were not told they were a part of an experiment. Group assignments were accomplished by the principle investigators, and given to the instructors.

Grading of the projects was standardized among instructors by providing detailed guidance to each instructor so as to make the process as objective as possible. In addition, the Course Director (the person responsible for administering the course) spot-checked each instructor's graded projects to ensure all projects were graded similarly.

#### IV. DATA REDUCTION

The following information for each student was collected.

1. Name
2. Squadron
3. GPA
4. MPA (Military Performance Average)
5. Major
6. Type group (1,2,3,4,5)
7. Civ Engr 310 Grades
  - A. Group only average
  - B. Individual effort only average
  - C. Overall average
8. Results of students critiques
  - A. Criteria
  - B. Instructor
  - C. Projects
  - D. Classmates
  - E. Course
9. Time Studies (The amount of time each group spent accomplishing the projects after Block 1-the 1950s Project, and Block 2-the 1990s project)
 

Items 1-5 and 8 were obtained from the Academy's Registrar, and items 6, 7 and 9 from data collected from the course.

From the data, the following hypotheses were tested:

  1. The method of group assignment affects individual and group performance.
  2. The method of group assignment affects students' attitudes toward the material, the course, the instructor or their classmates.
  3. The method of group assignment affects group efficiency.

Individual grades, group grades, and overall grades were compared across assignment methods. Likewise, student attitudes regarding criteria, instructor, projects, classmates, and the course were compared by analyzing responses to an end of course critique as shown in Table 2. The time required to complete both the 1950s and the 1990s projects were also

compared across groups. A T-test<sup>7</sup> was used to determine if differences from the control (self-select) were statistically significant. An F-test<sup>7</sup> was used to determine if there was evidence that the variations between the control and other groups were not equal. If there was evidence that variations were not equal, an estimated T-statistic<sup>7</sup> was used to determine if differences from the control were statistically significant.

## V. RESULTS

The results of this study are summarized in Table 3. The first number for each entry represents the mean value of the parameter. The number directly below the mean represents the sample variance. The asterisks identify parameter values that

GROUP	1	2	3	4	5
Interest GPA	Hetero Hetero	Homog Hetero	Hetero Homog	Homog Homog	Self Select
Individual Grades (%)	81.4 0.35	82.4 0.23	82.6 0.28	82.3 0.35	82.3 0.34
Group Grades (%)	85.3 0.28*	87.7* 0.09*	87.5* 0.17	86.7 0.28*	86.0 0.16
Overall Grades (%)	83.1 0.19	84.7 0.10*	84.8 0.16	84.3 0.20	83.9 0.17
Criteria	6.44* 2.69	6.95* 1.94*	6.77* 1.61*	6.09 2.67	5.77 3.07
Instructor	6.64* 3.04*	7.49* 2.17*	7.42* 1.37*	6.18 3.70	5.58 5.10
Projects	5.61 7.06	5.64* 6.62	5.36 6.07	4.93 7.68	4.94 8.77
Classmates	6.54 2.73*	6.28 5.09	6.67* 2.89*	6.10 4.65	5.93 5.09
Course	5.40 4.62	5.71* 5.56	5.60* 4.14	5.29 4.55	4.74 4.63
1950s Project (hrs)	37.48 18.5	33.22 13.8	41.45 26.7*	47.32* 18.1	33.37 14.4
1990s Project (hrs)	55.85 25.5	49.59* 15.8	57.20 18.5	67.32 20.3	57.31 16.8

The first number for each entry represents the mean value of the parameter. The number directly below the mean represents the sample variance. The asterisks identify parameter values that are statistically ( $P < 0.05$ )<sup>(7)</sup> different from the values for the control group (self-select).

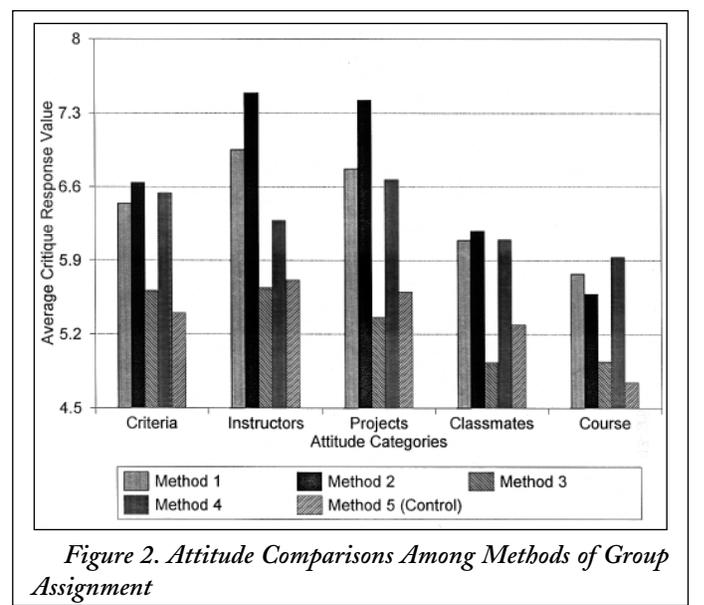
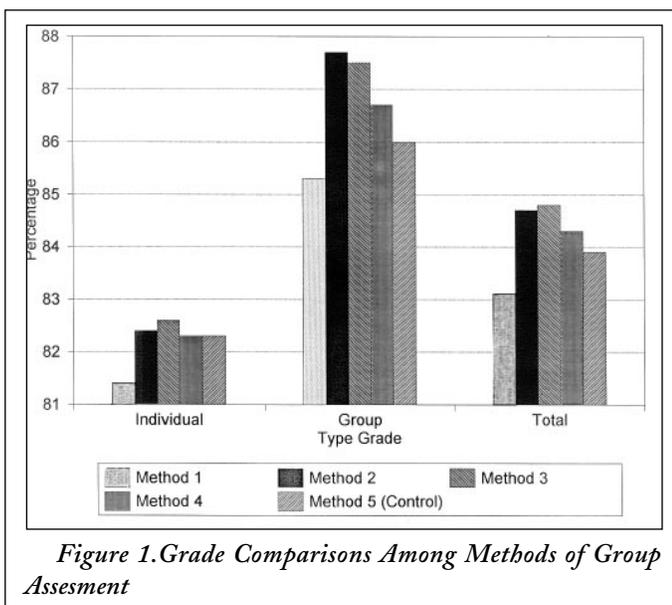
*Table 3. Summary of Results*

are statistically ( $P < 0.05$ )<sup>(7)</sup> different from the values for the control group (self-select).

## VI. DISCUSSION OF RESULTS

The results of the grade study are shown in Figure 1. Once again, the methods of assignment are as previously defined with method 5, self-select as the control. For grades determined from individual effort, there were no statistically significant differences between the control and any of the other methods. Likewise for the overall total grades. For group grades, though, students grades were significantly higher for methods 2 and 3, while there was no significant difference for methods 1 and 4 compared with the control. Also, from Table 3, it can be seen that method 2 has the lowest variance in grades. The higher grades with lower variance indicates a better, more consistent performance among groups as well as across group members. The significantly higher variations for methods 1 and 4 indicates a larger range of group performance. It may be for method 2 that students of similar interests find it easier to communicate and work with each other. Also, different GPAs may influence group organization with a natural leader (high GPA) and those that are more likely to prefer to be assigned tasks to complete their portion of the project. This may also impact the group and allow it to perform more efficiently and effectively. Nonetheless, it is appropriate to conclude that group selection had only slight effects on graded performance.

The results of the attitudes study are shown in Figure 2. For criteria, responses for methods 1, 2 and 4 are statistically significantly higher than the control, while there was no significant difference for method 3. The same results occurred when considering the responses rating the instructor. The only significant increase in ratings for the projects was for method 2. The only significant increase in responses toward classmates was shown by method 3. The responses for methods 1, 2 and 4 were significantly higher for the overall course rating. Although not all differences were significant, method



5, the self-selected control, generally has the lowest ratings of all methods tested across the five categories. In most cases, as seen in Table 3, method 5 also yields the largest variances in responses. It appears that for self-selected groups there is a large range of attitudes about all aspects of the course, with an average rating below that of the other methods of group assignments. No direct measures were taken concerning how students self-selected in method 5, but it is reasonable to assume previous acquaintances and proximity were factors. Thus, self-selected groups may be more "social" entities than other groups. This type of group may actually encourage discontent about all aspects of the course (including the instructor). The results of the Time Study are shown in Figure 3. The only statistically significant differences from the control occurred for method 4 for the 1950s project and for methods 2 and 4 for the 1990s project. Students assigned by method 2 have the least amount of time invested in the projects, while those assigned by method 4 have the greatest amount of time. It is also interesting that most of the four selected groups took a little longer on the first project but then appeared to increase their efficiency during the second project.

## VII. CONCLUSIONS

1. Appointed groups with a mixture of homogeneity and heterogeneity perform better (earn higher group grades) when compared with self-selected groups.

2. Allowing students to select their own groups results in the poorest attitudes about the course, their instructors, the projects, their classmates, and other criteria.

3. Method 2 of group assignments, heterogeneous with respect to GPA and homogeneous with respect to interest, appears to be the most effective method of group assignment when considering: (1) group performance (group grades), (2) attitudes about the course and its administration, and (3) efficiency in the use of time for this particular course.

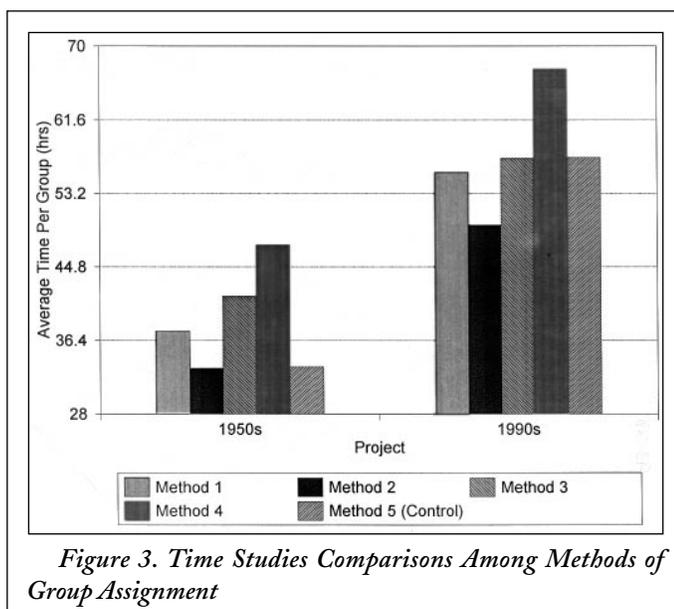


Figure 3. Time Studies Comparisons Among Methods of Group Assignment

Method	1	2	3	4	5
Instructors	A	B	E	H	G
	B	E	D	G	C
	C	F	E	C	C
	D	E	D	G	H
	F	D	A	G	

Table 4. Instructor Assignments by Method

## VIII. CAVEATS

1. Results may be contingent on the nature/type of group tasks. Generalization to other courses should be done cautiously.

2. The greatest advantage in the attitudes for methods 2 and 3 appears in the instructor category. Since this was a factor that was supposed to be randomized across methods, it might reflect a nonrandom distribution of instructors. A review of the instructor assignments resulted in the distribution shown in Table 4

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