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For Class Projects:
A Test of Two Methods

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Thomas E. Muller, Ph.D.
Associate Professor of Marketing
Faculty of Business
McMaster University
Hamilton, Ontario
Canada, L8S 4M4

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ABSTRACT

Beheshtian-Ardekani and Mahmood [1] recently proposed a method of assigning students to groups for class projects which considers a student's background, in order to achieve a balanced distribution of student skills among group members. By creating balanced groups of experienced and inexperienced students, they had assumed, but not shown, that the instructor would be giving weaker students a better chance to learn from the stronger members of a group, there would be greater synergistic learning effects, and students would be happier with the project experience. This experiment takes their approach to assign students to balanced groups using a people-sequential heuristic, then compares students' experiences with the group project against the experiences of students assigned randomly. The results show that balanced groups have a modest advantage over groups that are formed randomly. Students in balanced groups felt slightly more satisfied with and challenged by the group, and shared the workload more evenly. By comparison, students in randomly-assigned groups were much less unanimous or homogeneous in their sentiments about the quality of the group-project learning experience.

INTRODUCTION

Beheshtian-Ardekani and Mahmood [1] recently developed and validated a method for assigning students to groups in university courses that require group project work. Their tool offers the instructor a systematic solution to the ubiquitous problem of sensibly and equitably creating groups of students who are required to work jointly on a class project. Typically, instructors (including this author) who have a group-project component in their course syllabus will designate a group-size constraint and then, either allow students to form their own groups, or find a random or other convenient (and not-so-very-random) means of placing individuals into groups.

Beheshtian-Ardekani and Mahmood [1] rightly argue that most group projects require a considerable background of course prerequisites, analytical insight, problem-solving skills, communication ability, and even job-related experience. Even if all students in such a course possess the course prerequisites, there often are important inter-student differences in skills, experience and confidence. Thus, when project groups are formed without reference to a student's background, the likely result is an uneven distribution of student skills among project groups; through chance or a process of student self-selection, some groups may consist entirely of students with strong backgrounds, students who are relatively inexperienced, or a mix of these two types. In the interests of equity and student satisfaction, and to foster learning in both types, it is argued that groups should be constructed on the basis of a student's background preparation and in such a way as to achieve, in each group, a balanced mix of students with varying degrees of experience and preparation. Towards this goal, Beheshtian-Ardekani and Mahmood developed a two-step approach to the group-assignment problem:

1) Measure each student's background, or level of overall preparation, with a formal instrument that yields a student's background score;
2) Assign students to groups on the basis of their background scores--by using either a people-sequential heuristic or an optimization approach--where the objective is to minimize between-group disparity by making the within-group totals of student background scores as equal as possible.

Beheshtian-Ardekani and Mahmood designed a questionnaire--tailored to a course in management information systems--to measure the extensiveness of a student's background, and the questionnaire's reliability and validity were found to be reasonably good. In addition, they established the general feasibility of their balanced-group method, using either heuristic or optimization methods in order to create homogeneous groups with very similar total student background scores.

Missing from their study, however, was a comparative test of the efficacy of the balanced-group procedure. In comparison to other methods, how effective is this method in generating satisfaction with the group project work experience among students? Creating collectively equivalent groups of students using the balanced-group method requires the instructor to design a questionnaire that captures project-relevant aspects of a student's background of skills and experience, administer the questionnaire to all students in that course, code and score the responses, and (manually, or by computer) make the heuristic or optimal assignments. Given this substantial extra effort on the part of the instructor, does the technique produce an increase in students' perceptions of group harmony and fairness in the project workload allocation among group members, and satisfaction with one's performance?

The purpose of the study reported here was to experimentally test Beheshtian-Ardekani and Mahmood's balanced-group method against the random assignment of students to project groups. Intuitively, a random-assignment system is the fairest experimental control for the balanced-group treatment because a random assignment is impartial to students, tends to negate the effects of many extraneous factors that affect an individual student's performance in a group, and is commonly used because it is easy for the instructor to control and administer.

As yet, it is not clear whether the balanced-group technique is superior to the more common strategy of assigning students randomly, in the results that it produces. For the present study, Beheshtian-Ardekani and Mahmood's rationales for constructing well-balanced groups suggested the following hypotheses:

In comparison to students who were assigned randomly, students who were assigned to project groups by the balanced-group method feel

H_1: More satisfied, overall, with the group, itself;

H_2: More satisfied with their own level of performance on the project;

H_3: More strongly that their own portion of the group's workload was decided acceptably;

H_4: More strongly that the group effort had fully challenged them;

H_5: That the work contribution by each group member was more even, from member to member.

A further, more speculative hypothesis is that the mixing of very experienced and inexperienced students within balanced groups results in perceptions among the experienced members that their performance and learning in the project is being compromised or watered down by the weaker students. Therefore, there is

a negative correlation between student background scores and

H_6: Student satisfactions with the balanced group to which they were assigned;

H_7: Perceptions that the student was fully challenged by the balanced-group experience.

METHOD

Design and Subjects

To achieve a two-treatment experimental design, students from two consecutive yearly offerings of the same university course in business policy & strategic management were assigned to class project groups by one of two methods--random and the balanced-group method. All students were in the fourth and final year of a Bachelor of Commerce program. The project required an in-depth analysis of a lengthy business policy case, culminating in an oral presentation to the class and a formal written report, and the groups had about four weeks to work on their cases. The author, who was the instructor in both course offerings, took special precautions to keep the course content, schedule, and materials identical in every way, except for the experimental manipulation.

Instruments

A 12-item questionnaire was designed to measure project-relevant aspects of a student's background of skills and experience (see Appendix). To increase its content validity, the instrument was revised for greater relevance and completeness after obtaining inputs from graduating-year students who had several years' experience with business case courses and were familiar with prerequisite courses that were useful for business case analysis. With the

exception of questions B and D (which were scored to reflect their importance to the project), the numbers next to each response option represent the scoring scheme used; these scores were summed to yield a student's background score which could range between 10 and 50, where higher scores mean stronger student backgrounds. The questionnaire was administered to all 130 students in this study, and the data from it permitted a reliability analysis of the instrument, using Cronbach's alpha [2]. The reliability coefficient of .714 is almost identical to the .716 value for Beheshtian-Ardekani and Mahmood's student background measuring instrument [1, p. 95].

Also, a 4-item questionnaire was designed to capture a student's satisfaction with the group-project experience, at the completion of the project. Responding on seven-point Likert scales, a student indicated on a confidential form whether he or she strongly disagreed (1) or strongly agreed (7) with the following statements:

1. Overall, I was satisfied with the group to which I had been assigned for the case presentation project and report.
2. After working with my group on this project, I felt satisfied with my own level of performance.
3. The way my portion of the work on this project was decided and assigned within the group was quite acceptable.
4. I felt that the dynamics of our group helped bring out the best in me, on this project.

A reliability analysis, based on all the data collected with this instrument, gave a respectful Cronbach's alpha reliability coefficient of .841.

Finally, each member of a group used a confidential "peer evaluation" form to assess the relative contribution made by each of the other members. Using a constant-sum scale, every student in a group was asked to allocate points to

every other group member that would reflect that group member's effort on the project. These data were later analyzed to determine the extent of group cooperation and harmony from the perspective of each group member. Little variation among the set of peer evaluation points allocated by a student would reflect the student's perception of good teamwork and an even distribution of the total effort. High variation would indicate the opposite.

Procedure

The 82 students in the balanced-group treatment were assigned to 16 groups of five students (or six students, in the case of two groups). With each student's background score serving as the input, the scores were sorted in descending order and students assigned to a group, using the people-sequential heuristic. Beheshtian-Ardekani and Mahmood [1, p. 98] proposed two alternate methods for this assignment task--the people-sequential heuristic and the optimization approach (where deviations among the groups' total background scores are minimized). They failed to recognize, however, that their optimization approach has a major drawback. Even though the optimization model always gives an optimum solution, given the objective of minimizing the deviation between groups, it can result in highly polarized (bimodal) distributions of student background scores within some groups, while robbing other groups of the chance of having any top students at all. For example, when the project groups of their study were assigned by the optimization technique, one group ended up containing the two strongest students in the entire course, and in order to balance this lopsidedness, the optimization algorithm selected the two weakest students [1, p. 100, Table 5]. Another two groups each included two of the next four strongest students. The end result of their optimization procedure was that three of the 11 groups "used up" the top six students.

If there are n groups to be formed in a given course, why assign more than one of the top n students to a group? Better to apportion these strongest students so that each group has the benefit of one of them. Once this has been done, the next-best n students can be assigned, one to a group. These iterations are performed as many times as there are students to a group and until all students have been assigned, all the while working with the following rule: in the i + 1th iteration, examine the set of next-best n students remaining, and assign the student with the lowest background score to the group which has the highest cumulative score after the ith iteration; assign the student with next-to-lowest score to the group with the next-to-highest cumulative score, and so on, until that set of students has been depleted.

This is the procedure of the people-sequential heuristic method. Even though the approach might not always give an optimum solution (i.e., the smallest possible between-group variation in within-group total background scores), this is not a major drawback, as Beheshtian-Ardekani and Mahmood claim. Their own results show that the technique works quite well [1, pp. 98-99], but, more importantly, it tends to allocate the students more equitably because each of the n groups is assigned one of the best n students remaining after every iteration. Table 1 shows this heuristic assignment of students for the balanced-group treatment. The students are numbered sequentially (from 1 to 82, in parentheses) by the magnitude of their background scores. The last column gives a group's mean background score. The overall mean across all 16 groups is 31.43 (σ = .58).

Table 1 about here

In the following semester, another 48 students taking the same course were randomly assigned to 10 project groups of five (or four, in the case of two groups). Students in this class also completed the same 12-item student-background questionnaire. Their background scores provided a check on the overall comparability of the two sets of students in this experiment.[1] The scores also provided a basis for comparing the composition of groups assigned by the two methods, balanced group vs. random. Table 2 shows the composition of each group, by the background scores of its members, after the random assignment of students to groups. Note that, by chance, the two most experienced students in this course ended up in Group 1. Taking each group's mean background score, the overall mean, across all 10 groups is 31.23 (σ = 2.30). The coefficient of variation, $\frac{\sigma}{\mu}$, reveals four times as much variation in these group mean scores as in the balanced groups' mean scores (Table 1).

Table 2 about here

In both experimental treatments, and immediately after the completion of their project, a group's members independently answered the confidential 4-item questionnaire on their satisfaction with this group-project undertaking, and concurrently evaluated the performance of the other group members by allocating peer evaluation points.

RESULTS

The Group-Project Experience

Table 3 summarizes the differences in students' reactions to the group project, depending upon whether they had worked in a balanced group or in a

randomly-assigned group. Shown are the means and standard deviations of students' responses on five aspects of the project experience. All of the differences in means, between the two methods of assigning students, are in the hypothesized direction, but they are quite small. One-tailed $\underline{t}$ tests of these differences reveal that only three are significant at $p < .15$.[2] However, in both experimental treatments it was very apparent that responses to the first four items in Table 3 were stacked at the high end of the 7-point scale and their distributions were negatively skewed, indicating a general tendency among students to agree with the four satisfaction statements.

Table 3 about here

Satisfaction with the group to which a student had been assigned was significantly higher among those who worked in balanced groups (which supports Hypothesis H_1). Perceptions that the group effort had fully challenged them were also significantly higher among members of balanced groups (thus confirming H_4).

To test the extent of group cooperation or disharmony from the perspective of each group member, the mean and standard deviation of the set of peer evaluation points allocated by a student was used to compute the coefficient of variation, $\frac{\sigma}{\mu}$, of that student's point allocations to peers. Table 3 shows that, on average, peer evaluation points varied significantly less among students assigned to balanced groups than among those working in randomly-assigned groups. This finding supports H_5, since, more so than in randomly-assigned groups, students in balanced groups felt that group members, as a team, had contributed evenly to the task. Hypotheses H_2 and H_3 were not supported, as there was no significant difference between members of balanced

groups and members of randomly-assigned groups when it came to students' satisfaction with their own performance, or their perception that their share of the project work had been decided upon and assigned fairly among the group's members.

Although these contrasts in means favoring the balanced-group assignment method are generally quite small, the frequency distributions of three of the five criterion measures differ substantially in variance and shape between the two assignment methods. The results of two-tailed F tests for homogeneity of treatment variances are reported in the last column of Table 3. Among randomly-assigned students, there is significantly greater heterogeneity in the responses to the items satisfied with my group, my portion of the task was decided fairly, and group brought out the best in me. In general, for these three items, the distribution of responses is more negatively skewed than it is among balanced-group students, with a greater proportion of the answers occurring at the "strongly disagree" end of the rating scale. Interestingly, then, there is less unanimity among students who worked in randomly-assigned groups and greater scope for disagreement about the quality of the group project learning experience.

Correlational Analysis of Student Background Scores

Table 4 is a matrix of intercorrelations among the five criterion measures in Table 3, as well as a student's background score. The Pearson correlation coefficients in the lower-left triangle are for balanced groups, and in the upper-right triangle for randomly-assigned groups. For the students assigned to balanced groups, the results appear to support the hypothesized negative correlations between background score and a student's satisfaction with the group (H_6) and perception that he or she was fully challenged by the balanced-group experience (H_7). These correlations are very weak (-.16 and -.13,

respectively), so the conclusion that more experienced group members perceive that their performance and learning in the project is being compromised or watered down by the weaker students in their balanced group is somewhat tentative. As expected, for students in randomly-assigned groups, there is no systematic relationship between background score and these two criterion measures.

Table 4 about here

To partial out the effects of student background score in order to more clearly see the experimental effects of group assignment method, a separate regression analysis on each of the criterion measures in Table 3 was performed with student background score and group assignment method (dummy-variable coded) serving as the independent variables. The analyses show that, even after controlling for the effects of student background score, the findings reported in Table 3 remain intact.

CONCLUSIONS AND IMPLICATIONS

Let us review the problem addressed by this study. Most group projects require a considerable background of course prerequisites, analytical insight, problem-solving skills, communication ability, and, possibly, work-related experience. Yet, there often are important inter-student differences in such skills, experience and confidence. It makes sense, then, for project groups to be formed with reference to a student's background in order to achieve a balanced distribution of student skills among individuals within a group, by mixing less experienced students with more experienced ones. By doing this,

it is assumed that the instructor is giving weaker students a chance to learn from the stronger members of a group, there will be synergistic learning effects in balanced groups, and students will be happier with the project experience.

This experiment tested these assumptions by contrasting the reactions of students who had worked in heuristically-assigned, balanced groups with those of students who were assigned to groups randomly. From the viewpoint of the students themselves, the results show that balanced groups have a modest advantage over groups that are formed randomly. Students in balanced groups felt slightly more satisfied with their group, more challenged by the group, and there was more harmony within the group insofar as sharing the workload was concerned. Also, in comparison to balanced groups, students in randomly-assigned groups were much less unanimous or homogeneous in their responses on three counts: satisfaction with their group, agreement that their portion of the project work had been decided fairly within the group, and agreement that the group experience had challenged them. In other words, while most students in randomly-assigned groups were positive about these points, a greater proportion of them expressed negative sentiments about the quality of the group-project learning experience.

Against these modest advantages of the balanced-group assignment method, one must consider some tentative evidence that the more experienced students in balanced groups will be less satisfied with their group and feel less challenged by the group. Within balanced groups, there was a weak negative correlation between a student's background score and the student's agreement with these two satisfaction measures.

The question might be asked why these two methods of assigning students to project groups were not also evaluated by comparing the grades received by

students for their team projects. It was the express intention of this study to evaluate the balanced-group method from the perspective of the student, and not of the instructor. A comparison of grades assigned to completed projects would have introduced a different source of subjectivity, and the decision was made not to bring the instructor's subjectivity into the evaluation of the balanced-group and randomly-assigned group methods. To properly use the grading assessment as a criterion of efficacy would have called for the presence of several independent judges, who were blind to the experimental manipulation, to evaluate each group's oral presentation to the class and its formal written report, and then to combine these judgments into a group's project grade. Since this was not done, the grades assigned to each project would have represented the judgments of one individual (the author) who was not blind to either the experimental manipulation or the hypotheses.

Considering that the balanced-group assignment technique requires the instructor to design a questionnaire that captures project-relevant aspects of a student's background, administer the questionnaire to all students in that course, code and score the responses, and make the people-sequential heuristic assignments, does it produce worthwhile results? Ultimately, each individual instructor must decide what amount of effort is warranted in order to achieve any increase in student perceptions of within-group harmony, course-related learning, and a satisfactory group-project experience. The findings in this study suggest that instructors using a heuristic procedure to assign students to balanced groups, on the basis of their academic skills and experience, can to some degree improve the lot of students who must team up to complete a project.

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Footnotes

1. Overall, the two experimental groups were quite comparable. The background scores of students in the balanced-group treatment (mean = 31.39, s.d. = 5.68) matched those of students in the random-assignment treatment (mean = 31.31, s.d. = 4.84).

2. Since the study is exploratory, this researcher decided not to succumb to convention and, instead, to set alpha at a scientifically liberal level of $p < .15$. At the risk of clogging up the literature with false facts (Type I errors), the decision was made not to short-change already dull students by possibly committing Type II errors and thereby withholding from them the potential benefits of important and provocative new facts! If any doubts linger, a single replication of the experiment reported here ought to set the record straight. For a lucid discussion of this nagging issue, see [3, pp. 153-155, 528].

APPENDIX

12-item questionnaire to measure a student's background

For each question, please circle the number matching your response.

EXAMPLE: (1) Semester 6

A. In which semester are you currently enrolled?

1. Semester 6
2. Semester 7
3. Semester 8
4. Semester 9

B. How many previous courses have you taken (not including this course) where business cases were used as a method of instruction?

Scored as:

0 1. Two or less
2 2. Three to five
3 3. Six or more

C. Please calculate your average percentage grade, across all the case courses you have included in question B.

1. Between 50% and 59%
2. Between 60% and 69%
3. Between 70% and 79%
4. 80% or higher

D. Do you enjoy working on business cases?

Scored as:

0 1. Not at all
1 2. Very little
3 3. A fair amount
5 4. Quite a lot
7 5. Extremely much

E. Rate your level of confidence when analyzing business cases:

1. Not so confident
2. Somewhat confident
3. Quite confident
4. Extremely confident

F. Rate your experience/skill in formal oral presentations to a class:

1. Poor
2. Fair
3. Good
4. Excellent

[Continued overleaf]

APPENDIX (Cont'd)

G. With regard to the course 02-432 (Financial Management),

1. I have never taken it, or did not pass the course.
2. I have already taken it and have passed it.
3. I am enrolled in it this semester.

H. How much do you enjoy doing accounting/financial analysis?

1. Very little
2. Somewhat
3. A fair amount
4. Very much

I. How much do you enjoy working on marketing problems and strategies?

1. Very little
2. Somewhat
3. A fair amount
4. Very much

J. How much do you enjoy working on organizational/leadership/ interpersonal-relations problems?

1. Very little
2. Somewhat
3. A fair amount
4. Very much

K. Please indicate your cumulative average grade, to date, over all courses you have taken.

1. Between 50% and 59%
2. Between 60% and 69%
3. Between 70% and 79%
4. 80% or higher

L. How many years of work experience do you have?

1. None
2. 1 year
3. 2 years
4. 3-4 years
5. 5 or more years

Table 1: Results of heuristic procedure to assign students to balanced groups.

Group	Student's (Number) and Background Score						Group's Total Score	Group's Mean Score
1	(1) 45	(32) 33	(48) 31	(64) 28	(80) 21		158	31.6
2	(2) 44	(31) 33	(47) 31	(63) 28	(79) 21		157	31.4
3	(3) 42	(30) 33	(46) 31	(62) 28	(74) 23		157	31.4
4	(4) 42	(29) 33	(45) 31	(61) 29	(78) 22		157	31.4
5	(5) 41	(28) 33	(44) 31	(60) 29	(73) 23		157	31.4
6	(6) 40	(27) 33	(42) 31	(56) 30	(72) 24		158	31.6
7	(7) 40	(26) 34	(43) 31	(59) 29	(71) 24		158	31.6
8	(8) 39	(25) 34	(41) 31	(55) 30	(70) 25		159	31.8
9	(9) 39	(24) 34	(40) 32	(58) 29	(69) 26	(81) 20	180	30.0
10	(10) 38	(23) 34	(39) 32	(54) 30	(68) 26		160	32.0
11	(11) 38	(22) 34	(38) 32	(53) 30	(67) 26		160	32.0
12	(12) 38	(21) 34	(37) 32	(52) 30	(66) 26		160	32.0
13	(13) 37	(20) 34	(33) 33	(51) 31	(77) 22		157	31.4
14	(14) 37	(19) 35	(36) 32	(50) 31	(76) 23		158	31.6
15	(15) 37	(18) 35	(35) 32	(49) 31	(75) 23		158	31.6
16	(16) 37	(17) 35	(34) 33	(57) 29	(65) 27	(82) 19	180	30.0

Table 2: Results of random assignment of students to groups.

Group	Student's Background Score					Group's Total Score	Group's Mean Score
1	26	26	30	41	41	164	32.8
2	25	31	36	37		129	32.3
3	27	29	32	36	37	161	32.2
4	28	32	34	38	39	171	34.2
5	29	31	32	34	37	163	32.6
6	19	26	28	31		104	26.0
7	24	29	31	33	35	152	30.4
8	27	30	31	32	38	158	31.6
9	23	25	29	31	33	141	28.2
10	28	30	30	34	38	160	32.0

Table 3: Student reactions to the group-project experience, for balanced groups and randomly-assigned groups.

	82 Students in Balanced Groups		48 Students in Random Groups		Significance of Difference in Treatment	
Criterion	Mean	s.d.	Mean	s.d.	Means[a]	Variances[b]
Satisfied with my group	6.12	.95	5.88	1.38	$p < .15$	$p < .005$
Satisfied with my performance	6.00	.88	5.94	.95	n.s.	n.s.
My portion of task was decided fairly	5.98	.95	5.94	1.39	n.s.	$p < .005$
Group brought out the best in me	5.61	1.18	5.23	1.61	$p < .10$	$p < .02$
Coefficient of Variation of Peer Evaluation Points	.043	.085	.063	.097	$p < .15$	n.s.

[a] One-tailed results of *t* tests, with varying degrees of freedom, depending upon whether pooled-variance or separate-variance estimate was used in test.

[b] Two-tailed results of *F* tests for homogeneity of variances; df = 81, 47.

Table 4: Intercorrelations among five criterion measures and student background score, for balanced groups and randomly-assigned groups.

	1	2	3	4	5	6
Satisfaction with:						
1. Group	1.00	.46***	.78***	.82***	-.29***	.03
2. Performance	.55***	1.00	.48***	.56***	-.20**	.12
3. Workload	.39***	.52***	1.00	.67***	-.11	.14
4. Challenge	.59***	.63***	.42***	1.00	-.21**	-.06
5. C.V. of Peer Eval.	-.13*	-.11	-.13*	-.21***	1.00	-.03
6. Background Score	-.16**	.08	.09	-.13*	-.02	1.00

Note: Pearson product-moment correlations below the diagonal are for balanced groups; those above the diagonal are for randomly-assigned groups.

*p < .15, **p < .10, ***p < .05 (one tailed)

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