THE EFFICACY OF COLLABORATIVE LEARNING GROUPS IN AN UNDERGRADUATE STATISTICS COURSE

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Abstract. Assessment of the efficacy of collaborative learning group techniques is frequently subjectively based and often relies on casual comments from students or faculty. Despite this shortcoming, instructors searching for new and effective ways of teaching quantitative courses continue to experiment with collaborative pedagogy. This study examined the relationship between student performance on collaborative learning group assignments and students' examination scores in statistics. The results both challenge and support the efficacy of collaborative learning groups and suggest that faculty modify such techniques when evidence of student achievement cannot be empirically linked to the collaborative experience.

Statistics courses are found in the baccalaureate degree curricula of most social science and many professional disciplines. For example, nearly all undergraduate social science and business programs require one or more courses in statistics. Despite the importance of quantitative skills in the curriculum, students with limited backgrounds in mathematics and anxiety over statistics continue to be a challenge for faculty teaching such courses (Blalock 1987; Bridges et al. 1998; Cerrito 1999; Lomax and Moosavi 2002; Schumm et al. 2002; Soled 1991; Stork 2003). Not surprisingly, faculty assigned to teach statistics have tried a variety of approaches to help students develop a better understanding of quantitative methods. Most often, collaborative learning group techniques have been recommended to reduce student anxiety and improve statistical skills and knowledge (Auster 2000; Fischer 1996; Perkins and Saris 2001; Potter 1995; Schacht and Stewart 1992). This study will evaluate the effectiveness of one of these teaching strategies, collaboratively designed group projects, to enhance student learning of statistics.

In both the sciences and the humanities, faculties have endorsed collaborative teaching modalities at the college level (Gidden and Kurfiss 1990; Hawkes 1991; Longmore, Dunn, and Jarboe 1996; McKinney and Graham-Buxton 1993; Yamane 1996). Collaborative or cooperative learning refers to a variety of techniques involving joint intellectual effort by students.[2] Collaborative learning takes many forms and definitions, and the number of essential elements or requirements vary from one author to another (Goodsell, Maher, and Tinto 1992), but most collaborative approaches require students to work cooperatively in groups of two or

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more, mutually searching for understanding or solutions, or creating a product (Smith and MacGregor 1992).

Various forms of collaborative learning have been described in college level statistics courses (Auster 2000; Borresen 1990; Cumming 1983; Helmericks 1993; Perkins and Saris 2001; Potter 1995; Wybraniec and Wilmoth 1999). Instructors employing these techniques reported greater student satisfaction with the learning experience (Cumming 1983; Perkins and Saris 2001; Potter 1995), reduction of anxiety (Helmericks 1993; Schacht and Stewart 1992), and a belief that student performance was greater than students could have achieved working independently (Auster 2000; Helmericks 1993; Wybraniec and Wilmoth 1999). Surprisingly, most of these studies provided little or no empirical evidence that students' quantitative skills actually increased as a result of the collaborative experience. Assessment of the effectiveness of collaborative strategies was frequently subjectively based and often relied on casual comments from students or faculty. More rigorous evaluation data, such as empirical evidence of students' learning, was rare (Borresen 1990; Helmericks 1993; Perkins and Saris 2001).[3] While not without some merit, "casual" data (such as comments based on informal impressions), or even quantitative measures of student satisfaction (such as teaching evaluations or alumni surveys) do not adequately assess whether students have learned from a particular technique (Chin 2002; Huberty 2000; Lucal et al. 2003; Wagenaar 2002; Weiss 2002).

Few researchers have conducted studies to determine whether collaborative learning group strategies for teaching quantitative skills are statistically associated with student achievement. Despite this shortcoming, instructors searching for new and effective ways of teaching statistics continue to experiment with collaborative pedagogy. Consequently, an investigation of the efficacy of collaborative techniques on students' learning of statistics is timely. The purpose of this study is to assess the relationship between student collaboration and their statistical skills and knowledge. Specifically, I measure the effect of student performance on collaborative learning group assignments on examination scores in an undergraduate statistics course.

This study is germane to teaching faculty in general, and to those teaching statistics in particular. First, it has implications in the development of more effective techniques for teaching one of the most challenging courses in the undergraduate curriculum (Bridges et al. 1998; Stork 2003). Second, by assessing the relative effectiveness of collaborative strategies (such as group projects) and approaches that are more traditional (such as individually administered quizzes), this study helps teachers identify more effective ways to enhance student learning.

Data and Methods

Institutional Context

The study was conducted at a small (approximately 850 students) state-supported baccalaureate degree-granting university in the United States. The "Carnegie Classification" describes the institution as a Baccalaureate College–Liberal Arts (McCormick 2001). The institution is coeducational (70 percent women; 30 percent men), ethnically diverse (59 percent ethnic minorities), and comprised predominantly of nontraditional age (79 percent, twenty-five years of age or older) students. Eighty-two percent of the student population is employed (47 percent working more than thirty-one hours per week) and all students commute to the campus.

Course Description

Social Science 310 (Statistical Techniques) is an undergraduate course taught in the division of social sciences. The course prerequisite is college algebra (or a higher level mathematics course) with a grade of "C" or better. Social Science 310 is one of two methods courses required for all social science majors (including anthropology, economics, political science, psychology, and sociology) at the university. In addition, the course fulfills a core requirement for professional studies majors (including business/accounting and public administration). As a result, approximately 70 percent of the students enrolled in Social Science 310 are social science majors and 30 percent come from professional studies. The course is designed to provide students with an introduction to descriptive and inferential statistics.

Sample

Student data derived from enrollment lists and my class records for eight sections of Social Science 310 that I taught between 1996 and 2003. Complete information was obtained for 233 of the 276 students enrolled in the course at the beginning of each semester, for an 84 percent response rate. Student withdrawals from the course prior to the end of the semester accounted for the missing data. The class met for seventy-five minutes twice a week during a sixteen-week semester. My course consisted primarily of lectures on descriptive and inferential statistics that paralleled chapters in the text and readings in a Statistical Package for the Social Sciences (SPSS) booklet. Requirements for the course included three examinations: examination 1 (15 percent), examination 2 (20 percent), and the final examination (35 percent); two collaborative learning group projects worth 10 percent each; and twelve quizzes worth a combined 10 percent. Homework was assigned as a diagnostic tool, but not collected nor awarded credit. Students who reported difficulty with an assignment were invited to seek the assistance of the instructor prior to the recommended homework completion date. Although the text (most recently Levin and Fox 2003) and SPSS booklet (most recently Stangor 2000) changed as new editions became available, lectures, homework assignments, quizzes, group projects, examinations, and grading structure were essentially constant across the eight sections of the course.

Measures

Dependent Variables

This study employed two dependent variables: total number of points scored on the first examination; and total number of points scored on the final examination. The maximum number of points a student could earn on each test was one hundred. Examinations required students to manipulate data (such as perform computations) and to interpret data. During each test, students were allowed to use a calculator, textbooks, lecture notes, quizzes, homework, and group projects. All students were required to complete the examinations independently during a seventy-five minute class period.

Independent Variables

Course requirements included the completion of two group projects. Approximately four weeks prior to each projects' due date, I asked students to organize themselves into groups of two to four members.[4] I allowed each group to decide how to divide the work, but required each member to be involved in all stages of the project. Students were also reminded that they were collectively responsible for their projects and they would receive a group grade. To discourage "free riders," individuals who contribute little or nothing to the project, students were asked to apprise me of members who did not attend group meetings or were not performing their share of responsibilities. I informed the class that if an individual did not contribute his or her fair share to a project, I reserved the right to lower his or her grade accordingly. After the initial group formation, students met outside of class. My role was that of advisor; I encouraged students to meet with me when they had questions and invited them to submit rough drafts of their papers.

Group project 1 was designed to familiarize students with material that would appear on the first examination. Therefore, the project emphasized both computation and interpretation of descriptive statistics. Working in groups, students were required to use SPSS to compute frequency distributions, cross-tabulations, and descriptive statistics (such as measures of central tendency and dispersion) for nominal, ordinal, and ratio scale variables. After obtaining a printout the group was asked to interpret the data and write up the results in a two to three page typed and double-spaced paper. Group project 2 was designed to parallel material that would appear on the final examination, such as correlation and regression. Groups were required to select one scholarly article from a packet I placed on reserve in the library. Each group was asked to discuss their article and interpret its findings. After thorough discussion, the group was required to write a two- to three-page paper demonstrating their ability to interpret the multiple regression analysis presented in the article. The grades awarded on group project 1 and group project 2 served as independent variables.

Approximately once a week during the final ten to fifteen minutes of class, a brief quiz was administered. The quizzes involved computations and interpretations similar to those required on the group projects. Students were allowed to use a calculator, textbooks, lecture notes, and homework in order to complete the quiz. All students were required to complete the quizzes independently. The first four quizzes covered descriptive statistics and parallel the quantitative skills required to complete group project 1, and assessed on the first examination. The last four quizzes administered in the course focused on statistical relationships and demanded quantitative knowledge similar to that required on group project 2, and assessed on the final examination. Each quiz was worth a maximum of ten points. The arithmetic averages of the first four quizzes, mean quiz (1–4), and the last four quizzes, mean quiz (9–12), were used as independent variables. There were additional independent variables. Individual characteristics controlled for included age, gender, and major. Class size, semester, and course meeting time were also measured.[5]

Results

A multiple regression technique was used to analyze the data.[6] The results both challenge and provide some support for the efficacy of collaborative learning groups on statistics examination performance. Despite being designed explicitly to prepare students for the course's first examination, group project 1 was not statistically associated (b = .05; p < .887) with test scores, while mean quiz (1–4) scores had a positive and statistically significant effect (b = 6.48; p < .001) on examination 1. This raises doubts about the merits of collaborative group learning tasks. On the other hand, group project 2 was a significant positive predictor (b = 1.63; p < .001) of student performance on the final examination. This is encouraging, because it suggests that students working collaboratively and receiving high grades on group project 2 increase their learning of the material and score more points on the final examination than students earning lower group project grades. However, the results for group project 2 are less reassuring when considered relative to the mean quiz (9–12) score's larger positive effect (b = 5.62; p < .001) on the final examination. As revealed by a comparison of the standardized regression coefficients, group project 2 (*Beta* = .205) exerted an effect on final examination scores that was less than half that for the mean quiz score (*Beta* = .564).

Group project 1 is not a predictor of examination scores, whereas group project 2 has a statistically significant positive effect on the final examination. Why? It is a challenge to explain this difference in view of the array of factors (many of which were not controlled in the present study) that can affect examination performance. Possible explanations include differences in student ability and motivation, continuity between group project tasks and examination material, or changes in group homogeneity in response to free riders.

The latter explanation is plausible based on my informal observations and anecdotal student comments. While working on group project 1, it was not uncommon for a few students to complain to me that some group members were not fulfilling their responsibilities. Interestingly, when I offered to intervene, these students almost uniformly requested that I not do so. They preferred to "not make trouble" and chose to "stick it out," for group project 1, but most of these students who reported that they felt exploited by free riders on project 1 sought out more reliable classmates for group project 2. Therefore, I suspect the collaborative learning groups formed for project 2 were more self-selective than those created for group project 1. The most conscientious students avoided free riders and found similarly motivated classmates. As a result, those groups received higher grades on project 2 than did those groups composed of less conscientious students, and as individuals, the more conscientious students earned more points on the final examination. Consequently, the positive effects of group project 2 on examination performance, compared to no statistically significant findings for group project 1, may reflect the formation of more homogeneous groups for the second group project.

Pedagogical Implications

The results of this study provide only limited support for the inclusion of collaborative learning strategies in my statistics courses. I am not convinced that group projects enhanced student learning. Hence, will I continue to require group projects in my statistics course? Yes, but not before making some modifications. First, I will make it increasingly difficult for students to free ride. For example, McKinney and Graham-Buxton (1993) recommend averaging individual and group grades on projects. Therefore, I may require that each student write at least one section of the paper and that the group submit a table of contents listing the sections that each student wrote. This approach would allow me to assign each student a grade for his or her individual contribution as well as awarding them a collective group project grade. Second, I will consider establishing permanent groups at the beginning of the semester. The groups could be formed voluntarily, assigned randomly, or based on ability (that is, determined by a pretest or students' background in mathematics) in which students are assigned to either mixed- or similar-ability groups (Borresen 1990; Cumming 1983). These modifications in group assignment procedures would provide an opportunity to compare the relative effects of different group conditions on learning outcomes. Finally, until I have more evidence to support the efficacy of collaborative learning groups on student learning of statistics, I will reduce the proportion of course grade dependent on group projects from 20 percent to 10 percent and increase the weight given to the cumulative quiz score from 10 percent to 20 percent.

Suggestions for Future Research

Obviously, the inconsistent effect of group projects on examination performance reported in this study may be due to factors unrelated to the efficacy of collaborative learning strategies, such as differences in students' ability and motivation. Nevertheless, the results suggest that faculty take some precautions before forging ahead with collaborative learning groups without more evidence to support their effectiveness. Yet my data are by no means representative of all institutions of higher education and the conclusions I draw are not meant to be conclusive. Therefore, I suggest the following areas for future exploration.

First, research is needed on the efficacy of collaborative group tasks to improve learning of statistics at different types of institutions and on different student populations. Modifications in group project design and implementation may be required for the effective application of collaborative learning in diverse environments. Second, more studies are needed that relate collaborative instructional practices to actual student learning. Using teaching evaluations, attitude surveys, and even the final grade in a course (because course grades are usually aggregate measures reflecting student performance on a variety of activities) as learning outcomes does not adequately measure whether a particular technique increased students' statistical skills and knowledge. I suggest using gains in information content-learning to assess outcomes (Gelles 1980). Third, there is a need for more experimental assessments of collaborative and noncollaborative statistics courses (Borresen 1990). This would include research designs that employ a systematic method of comparison, such as pretest and posttest and experimental and control groups (Chin 2002). For example, faculty assigned to teach multiple sections of statistics might use collaborative learning groups in one section and compare examination performance to a traditionally taught course.

Conclusion

During the period (1996–2003) that I taught the eight sections of statistics on which this study is based, student evaluations of my course were very high and exceeded the overall campus average. Evidence that students report high levels of satisfaction with my course is gratifying, especially when one considers the "notorious" reputation that a course like statistics has for many students. However, high teaching evaluations, juxtaposed with group projects that produce modest or no effect on examination performance, indicate some potential limitations for collaborative group learning tasks when teaching statistics. Faculty seeking new ways to teach statistics should continue to experiment with collaborative strategies, but they must systematically assess learning outcomes and be prepared to make modifications in the application of such techniques when evidence of student learning cannot be empirically linked to the collaborative experience.

Key words: collaborative learning groups, student performance, exam scores

NOTES

1. I would like to thank Audri Beugelsdijk for assistance with data entry and Kyle Cabral for library research. Thanks for their comments on earlier versions of this manuscript to Orlando Olivares, Susan Pelowski, and William Smith.

2. I use the term "collaborative" throughout this paper to refer to group projects that represent one type of "collaborative" or "cooperative" learning strategy. Preference for the term "collaborative learning" versus "cooperative learning" varies from one author to another, but both are used in the literature to describe group tasks that emphasize the learning of each individual and all members of the group (Goodsell, Maher, and Tinto 1992).

3. Helmericks (1993) reports that students in a collaboratively organized statistics course scored 5.75 percentage points lower on a final examination than students in a traditionally administered course. Surprisingly, despite the finding that students working collaboratively performed less well on the final examination, Helmericks concludes that collaborative testing transforms "the social statistics examination into a dynamic learning process" (1993, 287).

4. Although groups ranged in size from two to four members, unfortunately, I failed to collect data on the exact size of each group. Consequently, I was unable to control for the effects of group size on examination performance.

5. Tables presenting detailed coding information, descriptive statistics, and a correlation matrix for all dependent and independent variables used in the study are available from the author on request.

6. Complete information (SPSS output and tables) for all regression equations produced in support of this study is available from the author on request.

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