Using Small Groups to Promote Active Learning in the Introductory Statistics Course: A Report from the Field

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Abstract

Over several semesters, we changed from the traditional lecture approach to cooperative learning. After some initial difficulty, we found procedures that work in classes of 40 to 100 students. Data consist of final grade distributions, the number of students retained in the class, and responses on a questionnaire that asked students' attitudes towards the group activities. Working in cooperative groups resulted in higher final scores in two experimental sections than in a comparison course section. A higher percentage of students successfully completed the course in the experimental sections, and student attitudes toward the cooperative group experience were positive.

1. Why Use Cooperative Learning?

1 Researchers studying the use of cooperative structures at the college level have found positive results. In one study, the use of learning partners and peer monitors resulted in improved performance in problem-solving, on quizzes, and on tests (Dees 1991). In another study, students learned just as well in cooperative as in traditional settings and developed more positive attitudes toward mathematics (Davidson and Kroll 1991). Webb (1982, 1983) has gathered and analyzed data on student interactions that demonstrate that problem solving and concept learning may be enhanced by the use of cooperative groups. Students in cooperative structures performed better than their peers in traditional classrooms on questions involving higher level thinking (Johnson and Johnson 1979, Sharan 1980).

2 College courses in statistics involve concept learning, problem solving, and the development of higher level thinking skills. It was therefore hypothesized that students enrolled in courses in statistics might benefit from a structural approach to teaching that facilitates student interaction and cooperation. The present research was motivated by a concern over attrition in lower division statistics courses and the isolating and competitive climate of many undergraduate college classes.

3 There is a growing consensus among statistics educators that the introductory statistics course needs to be reformed (see, for example, Cobb 1993 and Snee 1993). Arguments for reform can be made in two areas. On the one hand we can argue that we should be teaching concepts over mechanics (see Watts 1991). A better understanding of the appropriate use and interpretation of

various procedures results from conceptual learning. Also mechanics are better handled by computer packages which can process data faster and more accurately than we can by hand. The Freedman, Pisani, and Purves (1978) text was the first major introductory text that gave significant space to concepts. We particularly like their discussion of the differences between experiments, surveys, and observational studies. This text marks a watershed in the emphasis of concepts over mechanics.

4 The second argument for reform is that students learn better and retain more if they engage in learning activities that require them to think and process information rather than passively listen to lectures. Hogg (1991) suggested that using cooperative learning techniques would promote active learning. Garfield (1993) summarizes relevant literature on cooperative learning and gives guidelines for getting started and examples of its use. Others have been developing active learning materials for use in statistics courses. Examples include Mike Perry's Statistical Education Projects at Appalachian State University (Perry and Kader 1992), Richard Scheaffer's Activity-Based Statistics Project at the University of Florida, and the Chance courses (Snell and Finn 1992).

5 These projects are part of a movement to create an introductory course that encourages students to construct their own knowledge of statistics by de-emphasizing the role of formal lecture in favor of active small group work. Greater emphasis is placed on concepts, relevant examples, and the use of statistical computing packages. But how are those of us who learned statistics in the traditional lecture-work-the-problems mode supposed to implement such courses?

6 This paper summarizes the authors' experiences with cooperative learning since 1990. We focus on sections of the freshman level course taught in 1990 and 1991. The section taught in the spring of 1990 was the last traditional lecture section we taught, and we tried two different approaches to cooperative learning in the fall of 1990 and fall of 1991. Besides suggesting methods for the formation and use of groups, we also examine the extra time that must be committed to the implementation of a new strategy. The purpose of this study was to investigate whether a cooperatively structured course where students work in groups would produce higher grades and result in greater retention of students in the course than the traditionally structured instructional method. We formally evaluated the students' response to their cooperative learning experience in these semesters. Anecdotal material from later semesters is included where appropriate.

2. The Setting

7 The setting is a university established as a land grant research institution located in a rural area of the northwestern United States with an enrollment of 11,000. Each semester the class met in 50-minute sessions on Monday, Wednesday, and Friday. The same text (Freedman, Pisani, and Purves 1978) was used each term. Tests, which were based on material covered in class, were similar in content and difficulty and scored using a key that predetermined the basis for the awarding of full and partial credit. The course requirements included two papers, two exams, and a comprehensive final exam. Weekly quizzes counted as part of the grade in the traditional semester and group activities counted as part of the grade in the cooperative learning semesters. Students cooperated on in-class group activities and on homework, but were individually responsible for the two papers, exams, and final.

8 There are several approaches used to form cooperative groups (Garfield 1993). Some studies use heterogeneous groups with high ability, medium ability, and low ability student membership (Lindow, Wilkinson, and Peterson 1985). Other studies use a narrower range of ability in groups (Webb and Cullian 1981). Cumming (1983) concluded that mixed ability groups were preferred over groups homogeneous in ability. For this reason, we used an approach that allowed some student choice while still mixing ability levels. Students were allowed to form pairs by self-selection. In our first cooperative learning semester, quads were formed by the instructor who mixed disparate pairs so that quads included two pairs with different genders, ability levels, and areas of study. In this way

the pairs were usually homogeneous and the quads were made as heterogeneous as possible. The students were given a description of group activities that explained the function of the pairs and quads. Over the semester, some quad members dropped the course or could not get along and thus quads became triads. There were also two groups of five formed. Pair and quad activities were maintained throughout the semester.

9 The pair activity consisted of collaboration on three questions presented at intervals during the 50-minute period. Every 10 to 15 minutes, pairs were presented with a question posed from the material being covered. Pairs had three to five minutes to think, share their thoughts, and answer the question. The three responses for each lecture were turned in at the end of the session, graded, and returned at the next class meeting. If a pair answered five of the nine questions for the week correctly, they were given automatic credit for the homework due that week.

10 Quad members were expected to assist each other with questions on the homework and to support each other's learning. Every Wednesday, the last part of the class was devoted to discussing the homework due on Friday. Quads were required to write up answers to homework questions on transparencies. During this 15-minute session, the instructor was available to answer questions from the quads. These problems were collected and randomly chosen for review with the whole class on Friday. This activity constituted the third question for Wednesday's lecture. Credit for the response was given only if no more than one member was absent. There appeared to be some reticence to participate in the quad activity; this may have been due to the theater style seating of the room or the absence of one or more group members. Quads were encouraged to form group study sessions outside of class. Outside meetings did not readily occur, perhaps for social reasons or some scheduling difficulty, and were not required or monitored.

11 Webb (1991) contends that use of a group reward structure encourages interaction and helping behaviors among group members. We offered group rewards in the form of bonus points awarded for group performance on each exam. Each person received six bonus points if the quad had at least one person who scored in the 90's and the quad average was in the 80's; four bonus points were awarded if the quad had two members who scored in the 80's and no one scored below 70; two bonus points were awarded if the quad average was in the 70's.

12 After evaluating the results of the first semester of cooperative learning (see below), we made significant changes. In the second cooperative learning trial, students formed pairs in the same manner described above, but quads were not formed. In the first cooperative learning semester, we also asked students about the effect of bonus points. Because of their indifference in response to this item (Item 9, Table 3), we dropped the bonus point system in subsequent semesters. Perhaps other reward systems would be successful, but we feel that students see value in the group activity in and of itself without rewards. The group activity was consolidated into a single 20-25 minute time period rather than three 3-5 minute breaks. This single group activity most often occurred after a 25-30 minute mini-lecture, but sometimes occurred at the beginning of class. Homework was assigned, but was graded only through inclusion of homework problems on some of the in-class questions. Grades were based on the same two papers, two hourly exams, and final, but the group activity scores completely replaced homework scores.

3. The Results

13 The major reasons for experimenting with cooperative learning were to increase completion rates, to improve student performance on tests and papers, and to improve students' attitudes towards the course and statistics in general. In Table 1 below, grades listed as F_e, F_q, I, and W are not considered passing. In the traditionally taught semester, 36% of the students did not pass the course. In the two cooperative learning semesters only 14% of the students did not pass the course. Our experience in these and subsequent semesters is that cooperative learning increases the student

success rate.

Table 1

Grade Distribution (%) by Group

	Grades							
Semester	A	B	C	D	F_e	F_q	I	W
Traditional (n = 76)	5	11	22	26	3	9	3	21
Cooperative 1 (n = 46)	11	30	43	2	2	5	2	5
Cooperative 2 (n = 40)	20	30	28	8	2	5	0	7

F_e: Earned F

F_q: Quit attending, received grade of F.

I: Incomplete, given if student has done satisfactorily within three weeks of end of semester but failed to complete all requirements.

W: Withdrew, given if student dropped course after first four weeks of semester, but before the ninth week.

14 Grades were based on two short papers (160 points), two hourly exams (200 points), a comprehensive final (200 points), and the homework/groupwork (120 points). All three semesters used the same two papers, similar hourly exams, and comprehensive final. These common grade components (560 of 680 points) were used to calculate the grade distributions in Table 1 and the averages reported in Figure 1. The traditional semester students struggled with the two papers more than their colleagues, but actually did slightly better on the first two exams. However, the class average on the final was 20 points lower than the average on the first two exams, leading to a class mean cumulative score half a letter grade lower than the cooperative learning classes (Figure 1). The median class averages based on the papers, exams, and final were 71.7, 77, and 75 for the three semesters (traditional, cooperative learning 1 and 2, respectively). Not only did a larger percentage of students successfully complete the course under cooperative learning, but those who completed the course earned higher marks.

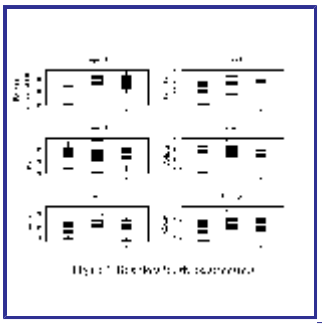

Figure 1 (6.7K gif)

Figure 1. Boxplots for Three Semesters.

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15 To assess students' qualitative responses to working in groups and active learning, we asked students in the cooperative learning courses to rate their degree of satisfaction with the group format, the value of working in pairs, and the degree to which they would like to work in this type of group format again. Students completed an anonymous questionnaire in the last week of classes which was kept confidential, collected by a student, and delivered in a sealed envelope to the department office. Results were tabulated after course grades were submitted. Eight areas of satisfaction were examined with five-point Likert items (Tables 2 and 3). Students were satisfied with the pair activity (Item 1) and valued working in pairs (Items 3, 4, and 5). They generally felt that they were pressed for time to complete the activities (Item 2), especially in the semester when the questions were introduced one at a time throughout the class period. Consequently, we consolidated the group activity to a single 'session' in subsequent semesters. This alleviated the time crunch somewhat in the second cooperative semester, but students still wanted more time for the group activity.

Table 2
Attitude Toward Group Structure (% of Respondents)

Cooperative Trial 1, N = 46, Respondents = 31
Cooperative Trial 2, N = 40, Respondents = 30

Question	Trial	1(low)	2	3	4	5(high)
1. Rate the degree of satisfaction with the lecture activity of pairs answering questions.	1	0	3	10	45	42
	2	0	6	27	37	30
2. Rate the degree of satisfaction with the time allotted for question and answer format.	1	6	23	26	32	13
	2	0	17	30	47	6
3. Rate the value of pair activity.	1	3	3	16	39	39
	2	3	0	13	40	44
4. Rate the value of the pair activity in terms of class performance.	1	3	3	20	45	29
	2	0	3	23.5	50	23.5
5. Rate the degree to which you would like to work in this type of pair format again.	1	3	10	10	29	48
	2	0	0	10	30	60

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16 Students felt that group members aided them in completing required work in class (Item 6a), but a number of groups did not get together outside of class, particularly in the first trial where quads were asked to work together (Item 6b). No information was collected as to why outside meetings did not occur. Among those groups who did meet outside of class, strong bonds were formed. A student who came into our statistical consulting center several semesters after she completed the course reported that her foursome still gets together. Groups generally felt they were communicating well and cooperating (Items 7 and 8).

Table 3
Ratings of Group Functioning (% of Respondents)

Cooperative Trial 1, N = 46, Respondents = 31
Cooperative Trial 2, N = 40, Respondents = 30

Question	Trial	1(low)	2	3	4	5(high)
6a. Rate the degree to which group members assisted you in completing homework. In class:	1	0	10	30	40	20
	2	0	6	24	33	37
6b. Rate the degree to which group members assisted you in completing homework. Outside the class:	1	43	7	29	14	7
	2	27	17	33	10	13
7. Rate the amount of cooperation among team members.	1	0	4	14	34	48
	2	0	13	0	33	54
8. Rate how well your group communicated.	1	0	7	11	45	37
	2	3	0	10	43.5	43.5
9. Rate your degree of concern with how well group members perform on exams which could result in bonus points for you. (Trial 1 only)	1	3	14	45	28	10

17 In the semester where we combined self-selected pairs into disparate quads, the students adjusted their groupings in ways they found natural and that worked for them. Some quads broke up. Other associations of various sizes were formed -- groups of two, three, four, and five. Observing these group interactions, we felt that students were not merely forming cliques of friends, but were forming groups that met their needs in attaining the group's goals. They appeared to seek out people with different skills. Group dynamics changed, some from class period to class period, because of absences and changing associations, but each group's structure remained coherent for long periods of time.

18 For this reason, the next semester (and subsequent semesters) we started with pairs and let them grow into natural groupings. Garfield (1993) acknowledges that forming groups by self-selection is an often-used strategy, but the kindergarten through high school literature on cooperative learning emphasizes the value of more purposeful involvement by the teacher. We think that college students are different; we are comfortable starting with pairs and letting the students themselves govern the group formation process. We do, however, keep track of what is going on in groups as we circulate to answer questions, and we do not hesitate to gently encourage group changes when we observe that a group is not functioning. Likewise, we do not assign formal roles to group members, but try to keep track of problems where someone is dominating the discussion or is being passive and not

contributing. In the few cases where this was a problem, we spent some time with the group drawing out the less vocal members.

4. Discussion

19 Our present experience suggests that students are more engaged in the course material and learn the material better when involved in collaborative groups than when presented with traditional lectures. However, cooperative structures should not be viewed as the sole method for improving instruction in a heavily concept-oriented course such as statistics. Course material must be organized to meet clearly defined course objectives, and class activities and lectures must be oriented toward giving students practice in applying difficult concepts.

20 In establishing collaborative structures in college classes, the instructor must also consider the impact on the instructor's in-class and out-of-class time. In courses with large enrollments, the initial establishment of group processes may take some commitment of course instructional time. We have found that this time is more than made up by the increased efficiency of assisting students in groups rather than as individuals. Questions may also be answered by group members, freeing the instructor to assist students in developing an understanding of the more abstract and difficult concepts.

21 An unexpected benefit we have experienced from cooperative learning is the day-by-day feedback the instructor gets from reading and grading the material turned in by the groups. Since these papers are relatively few in number, it is not a burden for the instructor to grade them. The instructor finds out what the students understand and what must be reviewed or retaught.

22 We have spent the intervening semesters refining the course materials and the group activities. We are sufficiently happy with the format of our second attempt that we have not changed the basic ingredients -- self-selected pairs growing into natural groupings, a mini-lecture followed by a significant group activity, daily collection and grading of group work, and individual accountability through short papers and exams.

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