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ABSTRACT

This study examined the changes in undergraduate students' attitudes and performance associated with the introduction of activities characterized by data exchange between the lecturer and students in large (up to 100 students) classes of introductory statistics for psychology majors. Participants were 195 undergraduates enrolled in the class during 2 consecutive quarters. The data exchange activities provided a manageable amount of data to work with during lectures. Data-generation and demonstration activities were complemented with lecture group activities. Students preferred lecture activities to plain lectures, and liked activities involving exchange of data more than simple group activities. Students were positive toward group work during lectures, and this experience made students feel more at ease in asking questions during lectures. Group work and activities also helped increase performance on course examinations. The implications for the use of information technology in the large lecture room to reinforce activities based on the exchange of data are discussed. An appendix contains an example of a data generating activity. (Contains 5 tables and 29 references.) (SLD)

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Poster Presented at the 108th Annual Convention of the American Psychological Association

Washington DC, August 4-8, 2,000

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Abstract

In this paper I describe the changes in undergraduate students' attitudes and performance associated with the introduction of activities characterized by data exchange between lecturer and students in large (up to 100 students) classes of introductory statistics for psychology majors. These data exchange activities provided a manageable amount of realistic data to work with during lectures. Data-generation and demonstration activities were complemented with lecture group activities. Students preferred lecture activities more than plain lectures, and rated them as being more helpful for coping with the course. Activities involving exchange of data were liked more than simple group activities. Students also were positive toward group work during lectures, and this experience in turn made students feel more at ease asking questions during lectures. Group work and activities also helped to increase the performance on the course exams. I suggest a possible way that information technology can be used in the large lecture room in order to reinforce activities based on the exchange of data.

Introduction

One of the rites of passage that students in psychology, sociology, political sciences, and other liberal arts disciplines have to endure is to take the menacing introduction to statistics course, which unfortunately is required for graduation, . This experience, sometimes frustrating to many students, is a permanent feature in many non-mathematical disciplines. For example, in the psychology curriculum the statistics course has remained constant across the years (Perlman & McCann, 1999). What seems to be changing is the way that the first statistics course for liberal arts students is being organized. As enrollment in institutions of higher education increases, the ideal setting of small introductory undergraduate statistics classes lectured by a senior faculty becomes more the exception than the rule. A more common setting consists of large lecture classes assigned to a faculty member in a large auditorium, and small lab sections taught by graduate assistants. Lecturers for these large courses face various problems: (a) the temptation to fall into a passive "I lecture, you copy" pedagogical schema, (b) the lack of interaction between lecturer and student and, (c) the students' negative expectations with respect to a "math" course (Moore, 1997a). Currently, traditional methods for teaching math courses are considered an unsatisfactory way to introduce non-math majors to statistical principles and techniques (Cobb, 1993). Pedagogical and educational terms like "activity-based courses"(Gnanadesikan, Scheaffer, Watkins, & Witmer, 1997; Scheaffer, Gnanadesikan, Watkins, & Witmer, 1996), "cooperative learning"(Courtney, Courtney, & Nicholson, 1994; Garfield, 1993; Potthast, 1999; Townsend, Moore, Tuck, & Wilton, 1998) and "authentic assessment" (Chance, 1997) have become common terms among statistics instructors. Many of these teaching innovations have shown their effectiveness in small or medium size classes. Although in these settings it is easy to gather data from the students to be used in class activities, the relatively small number of students make these data somewhat limited for certain analyses. On the other hand, group activities have been introduced in very large classes (up to 220 students) (Magel, 1996; Magel, 1998), where, the sheer number of students limited a fluent collection and analysis of whole class data during lecture time. In this paper I describe the changes in undergraduate students' attitudes and performance associated with the introduction of activities that emphasize the exchange of data between lecturer and students in large (up to 100 students) classes of introductory statistics for psychology majors. I implemented these activities within the setting of a standard lecture room. The middle-size classes provide a sufficiently large pool to obtain realistic data, and at the same time, a manageable amount of information to work with during lectures. Also, in response to the limitations that I perceived in using group activities in large classes, I propose a possible way to use technology to reinforce this activity-based and cooperative approach within the traditional large lecture room.

Group Activities and Small versus Large Classes

An activity-oriented approach reflects a more dynamic involvement of students in the learning process that favors a more data-analytical approach toward statistics at the same time. The goal is to provide a setting that triggers active participation of students in a variety of activities related to data gathering, data analysis, and communication of the analysis results in a cooperative learning environment (Velleman & Moore, 1996). This activity-based approach promotes the teaching of statistics more as an experimental science and less as a traditional mathematics course (Scheaffer et al., 1996). An activity-oriented class and a cooperative-learning approach to teaching are natural complements. Diverse definitions of cooperative learning exist (Garfield, 1993), but all share the same characteristic of using small, formal or informal, groups of learners that work together to complete a task or solve a problem (Garfield, 1995). In the cooperative-learning tradition, students learn in a face-to-face situation, working in small groups, and being responsible for their performance. The instructor introduces the activity, answers questions, and gives immediate feedback about group performance.

The introduction of group work and activities during lectures can produce dramatic improvements in the reception of the course, especially among college students with limited mathematical background (Conners, McCown, & Roskos-Ewoldsen, 1998; Courtney et al., 1994; Potthast, 1999; Townsend et al., 1998). Courtney et al. (1994) compared the effect of cooperative learning versus a traditional [illegible]re on graduate students in education who were taking a general statistics course. They found a large reduction in anxiety and improved feelings of efficacy among the students in the cooperative learning section. Keeler & Steinhorst (1995) compared undergraduate students who took a traditional lecture course versus those who participated in a cooperative-learning course. The authors found that students performed better and showed more satisfaction with the course in the cooperative-learning structure. Giraud (1997) described similar results. Students taking a cooperative learning version of an introductory statistics course improved their performance and indicated greater satisfaction with the course. Adding to these results, Townsend (1998) found that a cooperative-learning approach increased students' mathematical self-concept and decreased math-anxiety, although these effects were mediated by students' previous math training. Potthast (1999) found that students presented with the same topics in a cooperative-learning experience improved their performance on course tests, their attitudes with respect to statistics, and their confidence in their competence.

Most of the research mentioned above was done in classes that ranged in size between 15 and 44 students. Thus, we can consider those sizes as representing small classes. On the other side of the size spectrum, Magel (1996; 1998) introduced cooperative learning exercises into very large lecture class of between 140 and 220 students taking an introductory statistics course. Magel introduced group work by assigning students to teams. These teams were formed according to the seating arrangement of an auditorium with fixed seats. She used class activities that could be performed by the students in their own seats, and with data provided to each team in a worksheet, or with manipulatives, like M&M's, cards, etc., that each team used to generate their own data sets (Magel, 1998). She found evidence that the course test scores increased under the cooperative-learning approach. Also, students reported a marked preference for the group activities and rated them as very helpful for learning the concepts in the course. Magel's procedures encourage the introduction of a cooperative teaching approach in very large lectures, as well as in whole multi-section courses (Rumsey, 1998). However, a moderately large class, let's say up to 100 students, might expand the possibilities of large lecture group activities. On one hand, relatively fast data collection during the lecture session becomes a viable option, and the data sets collected would have an adequate size for most analyses or demonstrations. On the other hand, whole class activities that generate data can be combined with group activities where the data just collected is immediately analyzed. Thus, the class activities incorporate as a key characteristic the continuous exchange of data between the whole class, the groups and the lecturer.

Types of Activities: An Exchange Data Perspective:

In dealing with data, there are three components that an introductory statistics course has to address: producing data, organizing data, and drawing conclusions from data (Moore, 1997b). In any statistics course tailored to a specific audience (liberal arts, engineering, education students, etc.) the hands-on activities should involve these three components couched in the relevant content area. For example, psychology students will feel more involved with data relevant to some important psychological idea instead of an example from other disciplines (Conners et al., 1998). I consider that the impact of these activities would be even greater if they can combine all three components within the same lecture period, and when the population of reference is made up of the actual students in the class. In this perspective, the exchange of data between lecturer, whole class, and groups become one of the main characteristics of the lecture activities. Following this idea, I classified the activities I used in my classes into three categories: data-generating activities, demonstration activities, and graded activities.

In the data-generating activities, the emphasis was on statistics as a tool that provides a quantitative argument in support, or against, a content specific hypothesis. Psychology provides a rich area from which to draw short, dramatic, and simple experiments that expose students to in-lecture data generation. An exemplar of this type of data-generating activity is a demonstration of the well-known effect that memory for forward digit repetition is better than for backward digit repetition (Gardner, 1981). After I read aloud two sequences of ten digits, the students had to write down all the digits they could remember. For the first sequence, students had to recall the digits in the same order that they were read. For the second sequence, they had to recall the digits in the reverse order from which they were read. Once I displayed the correct sequences on the board, the students scored their number of digits recalled correctly under the two conditions. Afterwards, I asked for a sample of students' scores, which I wrote down on an overhead transparency, and then proceeded to work as a class on the analyses. Finally, I provided a new data set and requested that the class split into groups of four to analyze the new data using a paired-t test worksheet. At the end of the class I asked for the groups' conclusions and summarized the findings. In this type of activity, the interaction between the instructor and the students, and the corresponding exchange of data, is summarized in diagram (a) in Table 1.

Table 1
Diagrams of interaction lecturer-students for each type of lecture activity.

(a) Data-Generating Activity

Lecturer		Students
1. Sets up data producing task.	➪	2. Answer the task.
3. Provides scoring instructions.	➪	4. Score own responses.
5. Collects a sample of students scores and performs analyses.	➪	6. Follow analysis.
7. Translates results into a content argument. Assigns graded	➪	8. Engage in group work.
9. Walks around helping the groups.		

(b) Demonstration Activity

Lecturer		Students
1. Provides the class with a data set	➪	2. Obtain a sample from the data set. Operate on the sample.
3. Collects a sample of group results and analyzes it.	➪	4. Follow analysis.
5. States the general statistical principle. Assigns graded activity	➪	6. Engage in group work.
7. Walks around helping the groups.		

(c) Graded Activity

Lecturer		Students
1. Provides problem to be solved. Walks around helping the	➪	2. Engage in problem solving in groups.
3. Grades and gives feedback during next lecture	➪	4. Review their mistakes. Use the activities as references during

Statistics contains general principles, such as sampling distribution, variability, randomness, estimation, hypothesis testing, etc., that transcend specific content areas. These general principles form the basis for drawing conclusions from data using statistical inferencing, where the guiding idea is the distinction between population and sample, and the use of a sampling process. A large lecture class provides a good setting for activities that illustrate these principles because the whole class is a large population that generates data. The groups within the class, working with random samples from the whole class data, can produce sample estimates of a desired parameter. The lecturer, afterwards, can collect and summarize the groups' estimates and present these statistics to the class, together with the actual value for the whole class. This demonstration activity is basically a live simulation using the individual groups as replications. For example, to illustrate the idea of interval estimation, I distributed the scores of all the students in the first exam of the course. The groups used a random numbers table, and a special worksheet, to obtain a sample and to compute the 95% interval estimator for the class average. Once the groups finished their calculations, I asked twenty groups for their confidence intervals and plotted them on the board together with the actual value of the class average. If the groups do their work correctly, allmost all of their intervals will include the actual class average. The interaction and exchange of data between the instructor and the students in this type of activity is summarized in diagram (b) in Table 1.

Finally, a third type of activity can provide an opportunity to practice basic computations and interpretation of results, and graded feedback. In this graded activity, students work in groups to solve standard problems, and they are encouraged to ask questions at the lecturer and graduate assistants who walk around helping the groups. The interaction between the instructor and the students in this type of activity is summarized in diagram (c) in Table 1. In this type of group activity there is little, if any, exchange of data between lecturer and students. Also, we can see in the same table that the graded activities are the natural follow up for the two previous types of activities. Graded activities provide the lecturer direct contact with individual students. Also, they provide an invaluable feedback about students' understanding of the material, and allow experimenting with new types of items or assessments procedures.

Method

Participants

The participants comprised a total of 195 undergraduates (34 men, 161 women) enrolled in an introductory statistics course during two consecutive quarters. The course met in a large auditorium three times per week and in smaller lab sections two times per week. Although the course was offered by the Psychology Department, the proportion of psychology majors in this course varied significantly ($X^2 = 11.6$, $p = .009$) from 56.8% in Winter to 33% in Spring quarter. Juniors and seniors made up 77% and 80% of the students in Winter and Spring, respectively. Over 80% of the students in the two quarters were female. I was the lecturer in both quarters.

Materials & Procedure

Measures at the beginning of the quarter On the first day of class students answered a questionnaire inquiring about basic demographics, GPA, expected course grade, plans to pursue a graduate degree, and number of hours that they worked in a paid job. The :ionnaire also included a set of 14 seven-point Likert items examining four different areas: students' beliefs about the importance of statistics in their careers, their degree of insecurity/nervousness in handling math computations and taking a statistics course, attitudes about working in groups, and how prone they were to seek help from the course's instructor. Separate factor analyses for each quarter section produced 4 factors accounting for 69% and 63% of the total variance of these Likert items. The factor structure in both sections was the same, and the four factors coincided with the four areas the items were intended to cover. The first factor, labeled Math/Stat insecurity, included seven items of the type: "I am nervous about taking statistics" and "I usually feel insecure when I have to perform mathematical computations." The larger the score on this factor, the more insecure or nervous the student was in handling math computations and in taking a statistics course. The second factor, Stat Importance, included three items describing the importance of statistics in the students' intended careers and included items such as "I think that statistics will be useful in my profession," The larger the score on this factor, the greater the students' perceived importance of a statistics course. The third factor, labeled Predisposition to Ask for Help, included two items addressing the comfort level students had for directing questions to the instructor during class; higher scores indicated that it was easier for the student to request help in class. The last factor, labeled Preference for Group Work, included two items referring to preference to work alone or in groups in math courses. The higher the score, the higher the student's preference for group work. The same Likert items were applied at the end of the course to compare the impact of the activities on the four factors mentioned above.

Introduction of activities. Before the first lecture activity of the quarter, I asked the students to form groups of no more than three to work on the activity. Students were free to form their own groups and to move from group to group during the quarter. During the 26 lecture sessions in the quarter (50 minutes each), I introduced 12 graded activities, 6 data-generating activities, and 6 demonstration activities. Some lecture sessions did not include any activity. Other sessions included typical practice problems that I worked on the blackboard while the students kept track of the procedures on special worksheets.

For the data-generating activities, the students received an answer sheet and a calculation worksheet to perform the analysis. In the first half of the activity, I introduced the research content and asked students to participate individually, and in their seats, in a simple experiment. At the end of the task, I asked for a sample of students' data and wrote the data on an overhead transparency for all the class to copy. In the second half of the activity students split into groups. Using the calculation worksheet and the data on the screen the groups performed the requested analysis and stated their conclusions. With the help of a graduate assistant, I walked around the room answering questions about the task and helped groups to perform computations and to interpret the results. When most groups finished the analysis, I summarized the conclusions for the class. At the end of the class, I collected all the students' data to be used in future demonstration activities. This type of data-generating activity usually required between 30 to 45 min of class time.

For the demonstration activities, the students received the class data together with a random numbers table and a computational worksheet. I provided a brief reminder of the principle illustrated by the activity and then requested that each group work on these activities. Because most of the demonstration activities illustrated principles of inferential statistics, I instructed the groups to use the random numbers table to obtain a small sample from the data set provided and to perform the computations indicated on the worksheet. A graduate assistant and I helped students in the same manner as mentioned previously. Again, when the groups completed their task, I summarized their results on an overhead transparency and led students toward the general inferential principle being illustrated by the activity. As with the data-generating activities, at the end of the class, I collected all the results for use in future demonstration activities. Demonstration activities usually required between 25 and 35 min of class time.

During the graded activities, I handed out a set of questions for groups of 2-3 students to answer. While the students were working on the questions, a graduate assistant and I walked around the room answering questions and giving immediate feedback about the group answers. I collected and graded these activities. Graded activities required between 10 to 20 min of class time.

The course also included two lab sessions: (a) practice-problem labs, where a graduate assistant worked problems on the blackboard similar to the ones in homework assignments, as well as to the ones on the exams, and (b) computer labs, where graduate assistants introduced students to the use of Minitab (1998) to perform data analysis.

Results

Students' Evaluation of the Course

At the end of the course students rated on a scale of 1 (not helpful at all) to 5 (very helpful), with the intermediate value 3 (somewhat helpful), how helpful different components of lectures and labs were to them. Table 2 summarizes the results of this evaluation.

Table 2
Mean Ratings of Helpfulness of Course Components.

N = 191	M	SD
Practice homework labs	4.7	0.6
Graded lecture activities	3.9	1.1
Data-generating and demonstration activities	3.8	1.0
Computer lab activities	3.0	1.2
Plain lectures (without activities)	2.6	1.1

Note: Students answered using a scale from 1 (Not helpful at all) to 5 (Very helpful), with a middle value 3 ("Somewhat helpful").

A repeated measures Anova for the ratings of the 5 components showed significant differences among the five means, $F(4, 760) = 149.92$, $p < .001$. All the means were different among themselves, except the averages for graded activities and data-generating and demonstration activities. The least helpful aspect of the course was the plain lectures, and the most helpful was the practice homework labs. Lecture activities were the second most helpful component. Table 2 suggests two effects. First, plain lecture in large classes is not considered by the students to be as effective as hands-on activities, and second, the definition of "helpful" seems to be interpreted by the students as any activity that helps them to cope with solving discrete problems like the ones on the exams and homework assignments.

Table 3 shows the aspects of lectures that students mentioned as liking the most and the least. The table distinguishes between plain lectures and working example problems during lectures.

Table 3
Percentage of Students that Mentioned a Lecture Component as Liked Most or Liked Least

N = 191	Like Most	Like Least
Work on practice problems	44.2	0.5
Data-generating and demonstration activities	30.0	0.5
Graded activities	19.5	15.3
Plain lecture	3.7	80.5
Other mentions	2.6	3.2

Note: Entries represent percentage of mention of each lecture component.

For the most liked aspects, working on practice problems during class was the single most liked aspect of lectures, followed by demonstration activities and graded activities. Plain lecture and other mentions (such as, not enough time, classroom layout, etc) were the least mentioned as preferred aspects of lectures. However, the combined percentage of students that mentioned demonstration or graded activities (49.5%) was not significantly different from the percentage that mentioned only working on practice problems ($\chi^2 = .562$, $df = 1$, $p = .454$). Notice that data-generating and demonstration activities were in general liked more than graded activities alone. For the least liked component, plain lecturing was by far the least liked aspect of lecture sessions, while graded activities was the second least preferred component of lectures. The other three components received fewer mentions. Graded activities received an unexpectedly large percentage of mentions. This was mostly due to one of the quarter sections. During Winter only 5.5% mentioned graded activities as the least preferred component of lectures, however, during Spring quarter a significantly larger 24.2% did ($Z = -3.56$, $p = .0003$). For this last group the graded lecture activities, an integral part of the course grade, forced them to attend classes. A large proportion of the Spring quarter class was comprised of seniors who were involved in many other pre-graduation activities that seemed to interfere with class attendance.

In terms of group working preferences, at the end of the course 87.9% of the students preferred working in groups during lectures because they considered that it helped them to understand the course material. On the other hand, a statistically significant lower percentage of students, 66.1% , liked to work in pairs during computer labs ($Z = 5.02$, $p < .0001$).

Changes in Students' Beliefs.

Table 4 shows the average responses for the four belief indicators measured at the beginning and the end of the course.

Table 4
Mean Responses in the Pre and Post Application of the Likert Questions

	Pre N = 174		Post N = 180			
	M	SD	M	SD	t	p
Statistics Importance for Their Career	4.8	1.2	4.4	1.3	2.99	003
Math/Stat Insecurity	3.9	1.5	3.3	1.3	3.99	<.001
Group Working Preference	4.6	1.5	5.4	1.5	4.72	<.001
Help Seeking Preference	4.4	1.4	5.5	1.3	7.93	<.001

Note: Scale from 1 (Strongly disagree) to 7 (Strongly agree), with 4 (Neither agree nor disagree) as the middle point. The higher the average, the more the stats importance, Math/Stat insecurity, group work preference, and preference for seeking help from instructor.

Because the questionnaires were anonymous, Table 4 reports results of t-tests for independent groups. Congruent with the findings reported in the literature, the introduction of lecture activities and group work seem to reduce the level of math/stat insecurity among students. Also, the preference for group work and the predisposition to seek help from the lecturer increased significantly at the end of the course. On the other hand, the average assessment of the importance of statistics in the students' careers actually went down at the end of the course. This last result is mainly due to the Spring quarter students, whose perception of the relevance of statistics in their careers went down significantly at the end of the course ($t = 2.87$, $p = .005$). These differences might reflect the different composition of the two sections, with the Winter section having more psychology majors than the Spring section.

Performance and Attendance in the Course

Besides the graded lecture activities, the course used multiple-choice exams, quizzes, and weekly homework and computer assignments. With the exception of the exams and lab quizzes, students could work in groups for all other assignments. I used as indicator of the level of achievement of the class the total score on the exams, expressed as a percentage. Table 5 presents the averages in exams for the two quarter sections where I introduced lecture activities, and for similar quarter sections the year before, where I did not use lecture activities. Besides the lecture activities, the four quarter sections used the same textbook, lab formats, quizzes, and exams. Exams for all these sections covered the same material and they had similar formats. Also, students enrolled each year had a similar profile.

Table 5
Mean Score in the Course Exams by Quarter and Activity versus No-Activity based Course

	Winter			Spring		
	M	SD	n	M	SD	n
Lecture Activities	85.8	11.4	95	83.0	10.9	100
No-Lecture Activities	82.0	10.2	81	76.4	10.4	89

A 2x2 factorial Anova produced a significant main effect for activity vs no-activity based class, $F(1,361) = 21.174$, $p < .001$. Students in the activity-based classes obtained a larger average exam score ($M = 84.4$) than the one obtained by students in the no activity-based classes ($M = 79.2$). The interaction was not significant, $F(1, 361) = 1.537$, $p = .216$, however the main effect of quarter was significant, $F(1, 361) = 14.418$, $p < .001$. The Winter sections had a larger average exam score ($M = 83.9$) than the Spring sections ($M = 79.7$). This significant difference was not expected. A possible explanation is suggested by the differential attendance during Winter and Spring. I used the percentage of graded lecture activities that students in the activity based classes took during the quarter as indicator of lecture attendance. The Winter section ($M = 82.6$, $SD = 22.3$) had a substantially higher attendance to lectures, $t(193) = 2.68$, $p = .008$, than the Spring section ($M = 73.5$, $SD = 25.1$).

Discussion

The results presented in this paper support the idea that the introduction of lecture activities where students and lecturer exchange data within a large lecture is a viable procedure. These activities, together with group activities, have more potential to engage the learning process of the students than simple lectures. Students preferred the lecture activities introduced in the course more than the plain lectures, and they also rated them as being more helpful for coping with the course than straightforward lectures. However, data-generating and demonstration activities were liked more than simple graded activities. At the same time, the students were positive toward the group work in which they were engaged during lecture activities. Also, the more direct contact with the lecturer and graduate assistant while working in graded activities made students feel more at ease asking questions during lectures. Finally, there is evidence that the activities helped to reduce the initial mathematical insecurity of the students. As Magel found in a similar setting (1996), the effect of group work during lectures helped to increase the performance on the course exams. These results replicate in a consistent manner the effect of in-class group work on hands-on activities. However, the characterization of lecture activities as part of a continuous process of exchanging data between the whole class, the lecturer and the class groups is a fruitful approach for considering class activities.

Although there are excellent sources of class activities for small classes (Rossman & Chance, 1998; Scheaffer et al., 1996), and some implicit guidelines for large classes (Magel, 1996), I suggest that more attention has to be paid to create large class activities that emphasize data interactivity between lecturer and students. Regardless of the content area, a good data-gathering activity should (a) include short straightforward instructions and a simple task that can be performed quickly, (b) require basically paper and pencil, (c) allow students to remain in their own seats, (d) produce interesting data for the demonstration activities, and (e) motivate students to perform and compare their results in an atmosphere of friendly competition. In one of my most popular activities, which I call "The ridiculously difficult test", students answer six mutliple-choice items with four alternatives about topics that I know they don't know (i.e. multivariate statistics, poetry metric, history of Latin-America, etc.). At the moment that I read the right answers, the whole class splits into different camps that root for one or another of the alternative responses. This enthusiasm changes into true interest when, after asking a sample of students for their scores, I show them that their scores on the test resemble a binomial distribution with P = .25. In a similar way, a good demonstration activity should (a) use student's own data, (b) provide clear instructions and worksheets with all the required formulas, (c) require short computations, and (d) provide a "true" answer against which the groups can compare their "precision". For example, in the confidence interval activity described in this paper, I wrote down on the board the actual class mean, thus the groups could check immediately if they were correct. Finally, a good graded activity should (a) cover the content that the lecturer considers important, and (b) emphasize the cognitive demands to master that content (definitions, application of rules, problem-solving, etc.). The graded activities also provide an opportunity to expose students to new forms of assessment defined more in terms of the behaviors that we expect to observe in students after taking the course (Garfield, 1994).

The limitations in implementing group work in large classes with activities that exchange data are mostly related to time. Lecture preparation time increases dramatically. Activity worksheets have to be prepared ahead of time, and even when available from previous years, they need to be tailored again to the progress of a particular class. Producing materials for data-generating and demonstration activities is another time consuming task. However, the most serious drawback is the limited lecture time available. The introduction of regular group activities cut into the time available for delivering lectures. The instructor has to reduce drastically the amount of time devoted to delivery of information in class, which in turn, reduces the amount of coverage of material. On top of this, activities involving exchange of data between lecturer and students, like in the data-generating and demonstration activities mentioned above, take even more class time. However, during the two quarters when I introduced these activities, I was able to reach up to hypothesis testing for two independent samples.

In any case, the time invested in exchanging data during lectures might be reduced by the introduction of computers. Current instructional technology is increasingly based on the Web and assumes the interaction between a single user and a terminal outside the classroom. For example, in teaching Statistics, for social and behavioral science students, a lot of effort has been invested in creating web sites that integrate tutorials (Koch & Gobell, 1999; Varnhagen, Drake, & Finley, 1997), access to real data (Aberson, Berger, Emerson, & Romero, 1997), interactive software for data analysis (Lane, 1999), and even individualized testing and feedback (Stockburger, 1999). On the other hand, instructional technology in the lecture hall is being used mainly as a means to display information. One example of this is the increasing presence of multimedia presentation stations in university classrooms. A more ambitious application of technology in the lecture room is the Classroom 2000 project developed by the Georgia Institute of Technology. Classroom 2000 is a complex system of capturing traditional lectures for subsequent review on the Web (Abowd, 1999). In both cases, technology reinforces the transmission of the knowledge aspect of a typical lecture.

Technology can free lecturers from most of the verbatim transmission of information. A small portion of the lecture sessions must continue to be dedicated to reviewing the relevant content for the activity to be performed, but most of the transmission of knowledge has to be done outside the lecture hall. Maybe short multi-media mini-lectures on the course web-page will provide an attractive way to deliver this basic information (Becker, 1996; Koch & Gobell, 1999). On the other hand, in a course like the one described in this paper, the exchange of data between lecturer and groups can be facilitated by a course web-page that incorporates active server technology that handles the information exchange between lecturer and groups during lecture time (Stockburger, 1999). The course web page will deliver the activity to the groups, collect their responses and aggregate them into a data file that can be located in the same course web page in order for the groups to access the data and perform any required analysis. Alternatively, the aggregated data can be used by the lecturer to illustrate a particular concept. This implementation does not suggest that the lecture room is changed into a computer lab. Instead, the lecture room will incorporate unobtrusive terminals connected to the Internet that allow the groups to exchange data with the instructor during lecture time. Perhaps this type of interactive large lecture room, oriented towards work group, will be more prevalent in the future.

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Appendice

Example of Data Generating Activity

Digit Span Experiment

General Instructions

I am going to read aloud two series of 10 digits, from 0 to 9, with no repeated numbers. You will listen while I read the 10 digits in a series, and only when I finish the reading will you pick up your pen and write down the digits. In the "Forward Task" you will have to write down the digits in the SAME ORDER I read them. In the "Backward Task" you will have to write down the digits REVERSING THE ORDER in which I read them.

We will start with the Forward task. You will have to write your answers in the slots directly underneath the word FORWARD. Remember, when I finish reading, write down the digits in the same order that I read them. The digits are:

4 2 5 1 8 0 3 7 9 6

We will continue with the Backward task. You will have to write your answers in the slots directly underneath the word BACKWARD. Remember, when I finish reading, write down the digits in the reverse order from what I read. The digits are:

1 7 2 6 5 8 4 9 3 0

Students Answer Sheet

Digits Span Experiment

Do not write anything until the instructor orders it.

FORWARD:

____ ____ ____ ____ ____ ____ ____ ____ ____ ____

1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th

BACKWARD:

____ ____ ____ ____ ____ ____ ____ ____ ____ ____

1st 2nd 3rd 4th 5th 6th 7th 8th 9th 10th

No. Correct Forward:________ No. Correct Backward:__________

Students Working Sheet

Write down the results of 10 of the students in the class in the table below. We want to test if there is <u>any difference</u> in the number of correctly recalled digits in the Forward and Backward conditions. D = Forward-Backward.

Number or digits correctly recalled Forward and Backward recall.			
Subj.	Forward	Backward	D
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

(1) State Null and Alternative Hypotheses:
H_0: ________________ H_1: __________________

The alternative hypothesis is a ________ tail(s) hypothesis.
(one / two)

(2) We will use the t-test for correlated groups.

(3) Use as significance level $\alpha = .05$

(4) The test statistic for this test is : t_{obt} = ______________

Under the null hypothesis, the test statistic follows a _______________ distribution
(binomial, normal, t)
with ____ df.

(5) The critical values for the test-statistic are: _____________________

Therefore, the decision rule is: If __________________________ then reject H_0

6) Compute the value of the test statistic.
t_{obt} =
This value ________ in the rejection region, therefore we ___________ the _______________ hypothesis.
(is / is not) (accept / reject) (null / alternative)

7) Write one sentence in APA style that summarizes the result of the analysis.

Example of Demonstration Activity

Confidence Interval Practice

The table on the right presents the scores in the first exam of a course. Suppose that your group is working for the professor of the course and she asks you to find a quick interval estimate of the mean score in the class.

ID	Score	32	11	62	18
1	11	33	12	63	14
2	9			64	12
3	14	ID	Score	65	17
4	17	34	11	66	12
5	15	35	15		
6	18	36	10	ID	Score
7	10	37	16	67	14
8	15	38	11	68	12
9	15	39	13	69	14
10	14	40	20	70	12
11	17	41	13	71	11
12	10	42	12	72	3
13	15	43	18	73	14
14	16	44	15	74	13
15	10	45	15	75	14
16	17	46	9	76	13
17	14	47	3	77	20
18	12	48	15	78	14
19	15	49	17	79	14
20	8	50	12	80	10
21	10	51	14	81	16
22	9	52	12	82	19
23	17	53	12	83	18
24	14	54	14	84	11
25	16	55	7	85	12
26	12	56	16	86	13
27	13	57	13	87	14
28	16	58	20	88	12
29	16	59	11	89	11
30	10	60	15	90	15
31	15	61	18	91	15

Your group is in a hurry and you don't want to enter all the 100 values in the computer. Thus, the best alternative is to obtain a random sample from these 100 scores and compute the confidence interval using this sample.

- Using your random numbers table, take a random sample of 5 scores and compute the sample mean $\overline{X}$ and the sample standard deviation S.

$$\overline{X} = \frac{\sum X}{N} =$$

$$SS = \sum X^2 - \left(\sum X\right)^2 / N =$$

$$S = \sqrt{SS/N-1} =$$

- The point estimate for the population mean μ is: ___________.

- To obtain the 95 % confidence interval for the population mean the value of the degrees of freedom is ________. Therefore, the "critical values" for the lower and upper confidence limits are: + ________ and - ________

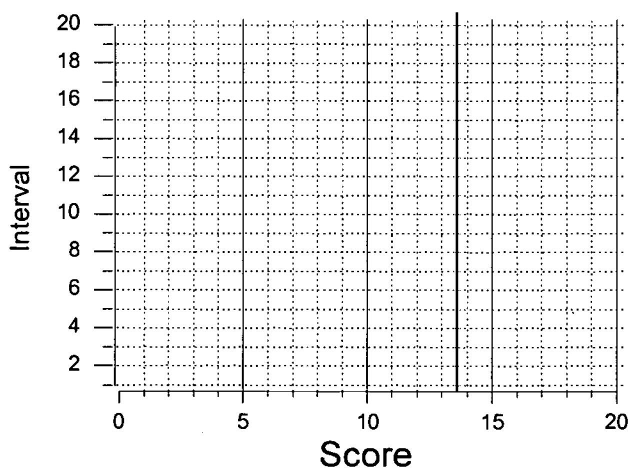
  - The lower confidence limit is: $\overline{X} - t_{\frac{\alpha}{2};N-1} \dfrac{S}{\sqrt{N}} =$
  - The upper confidence limit is: $\overline{X} + t_{\frac{\alpha}{2};N-1} \dfrac{S}{\sqrt{N}} =$

  - Thus, the 95 % confidence interval is (_______ , _________)

Your confidence interval will not be the same as the intervals computed by the other groups. We can illustrate the different intervals by plotting them on the following graph.

i	X	X^2
1		
2		
3		
4		
5		

We can count how many of the 20 intervals computed by the different groups in the class actually include the "population" mean of the 100 scores (13.57) that is represented by the thick vertical line in the graph. Since we use a 95% confidence interval, we expect to find that nearly all the intervals will include the actual population mean.



Example of Graded Activity

The cross tabulation below shows the answers of this class to the questions: "Which one of the following terms best describes your political views: Liberal, Moderate, or Conservative?" and "Are you left handed?".

If you select at random one student from the class, what is the probability that:

Rows: left-handed?   Columns: Political

	Liberal	Modert.	Conserv.	All
No	20.88	38.46	28.57	87.91
Yes	2.20	2.20	7.69	12.09
All	23.08	40.66	36.26	100.00

1) the student is politically conservative:______________

2) the student is left-handed:____________

3) the student is politically liberal and right-handed: ___________

4) What is the probability that a student is left-handed, given that the student has conservative political views?

5) Do you think that political orientation and left vs right handed are statistically independent? Why?

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