Journal of Statistics Education

Collaboration in Learning and Teaching Statistics

Cary J. Roseth, Joan B. Garfield, and Dani Ben-Zvi
Michigan State University, USA, University of Minnesota, Twin Cities, USA, University of Haifa, Haifa, Israel

Journal of Statistics Education Volume 16, Number 1 (2008),
www.amstat.org/publications/jse/v16n1/roseth.html

Copyright © 2008 by Cary J. Roseth, Joan B. Garfield, and Dani Ben-Zvi all rights reserved. This text may be freely shared among individuals, but it may not be republished in any medium without express written consent from the author and advance notification of the editor.

Key Words: collaboration, cooperative learning, collaborative teaching, statistics education

Abstract

This paper provides practical examples of how statistics educators may apply a cooperative framework to classroom teaching and teacher collaboration. Building on the premise that statistics instruction ought to resemble statistical practice, an inherently cooperative enterprise, our purpose is to highlight specific ways in which cooperative methods may translate to statistics education. So doing, we hope to address the concerns of those statistics educators who are reluctant to adopt more student-centered teaching strategies, as well as those educators who have tried these methods but ultimately returned to more traditional, teacher-centered instruction.

1. Collaboration in Learning and Teaching Statistics

This paper builds on the premise that statistics instruction ought to resemble statistical practice, an inherently cooperative enterprise. Statisticians typically need to work on teams and communicate effectively with their collaborators, who may have little or no background in statistics. Today, nearly all graduate and even undergraduate programs in statistics prepare their students to be statistical consultants, and some also prepare their students in communication skills, realizing that statistical practice requires high-level skills in teamwork, collaboration, and communication.

Collaboration is not just an end goal of statistics instruction but also a means to help students learn statistics. Indeed, educators, psychologists, and statisticians alike have all called for students to have opportunities to work together as they learn statistics (e.g., Garfield, 1993; Hogg, 1992; Lovett & Greenhouse, 2002). The recently adopted GAISE guidelines (see Franklin & Garfield, 2006) make similar recommendations explicit, stating that, “As a rule, teachers of statistics should rely much less on lecturing, and much more on the alternatives such as projects, lab exercises, and group problem solving and discussion activities” (http://www.amstat.org/education/gaise/GAISECollege.htm).

While collaboration and student-centered, active learning are relatively simple ideas, implementing such methods is not. Statistics educators may reasonably ask how these teaching methods should be translated to the statistics classroom. As highlighted by the 7th International Conference on Teaching Statistics (ICOTS), working cooperatively in statistics education involves obvious benefits and challenges, with the latter raising questions about the degree to which cooperative methods actually translate to statistics education (Osvaldo Fabbroni, Chang Lee, Lievesley, Martin-Guzman, Morettin, & Rossman, 2007). This paper addresses this issue by providing specific examples of how statistics educators may apply a cooperative framework to classroom teaching, student assessment, and teacher collaboration. Thus, the purpose of this paper is a practical one, connecting a theoretical framework to guidelines and materials for statistics teachers.

We divide the paper into two sections, the first focusing on cooperative learning in the classroom and the second on collaboration among statistics educators. The argument is made that collaboration among both parties – i.e., among students and among educators – ultimately enhances and sustains the other.

2. Cooperative Learning in the Statistics Classroom

This first section focuses on practical tips and materials for successfully implementing cooperative learning methods in the statistics classroom. We begin, however, by differentiating the terms peer learning, active learning, cooperative learning, and group work. We also introduce social interdependence theory (Deutsch, 1949, 1962; Johnson & Johnson, 1989, 2005), the guiding theoretical framework for much of the research on the effects of cooperation.

2.1 Definition of Terms

How is cooperative work different from group work? To use cooperative learning effectively, statistics teachers must realize that not all groups are cooperative groups. Study groups, lab groups, and discussion groups may be groups, but they are not necessarily cooperative. In fact, while some kinds of groups facilitate student learning and increase the quality of life in the classroom, other types may hinder student learning and create disharmony and dissatisfaction in the classroom (Fiechtner & Davis, 1992).

How is cooperative learning different from active learning? Cooperative learning and active learning are often used interchangeably to describe instructional methods that allow students to solve problems, participate in activities, and discuss content with students. Importantly, cooperative learning is a form of active learning, but active learning is not necessarily cooperative. An important distinction is that cooperative learning methods capitalize on the motivational and epistemic processes occurring between *students rather than within* any one. This means that cooperative learning methods derive engagement and interest from the way students' individual goals are linked to each other, rather than rely on individual curiosity, work ethic, or the provocative nature of the curriculum, activity, or lesson plan. Put simply: Knowing that your peers' success depends on your own – that you "sink or swim" together – is a powerful motivator (Kohn, 1986).

An example helps to illustrate the distinction between cooperative learning and active learning. Consider an activity focusing on understanding the standard deviation (for the original lesson plan see http://www.causeweb.org/repository/StarLibrary/activities/delmas2001). Student pairs must decide whether one histogram has a larger standard deviation than another histogram, or if the two histograms have the same standard deviation. This lesson is clearly active in that students are not passive recipients of the teacher's knowledge. Simply asking students to complete the activity however – even asking students to work *together* in completing the activity – does not make the activity cooperative. Indeed, it

is possible that some students may choose *not* to engage in the activity, preferring instead to let their partner do all of the work.

Now, consider how the histogram activity may be structured cooperatively. Student pairs are again presented with several pairs of histograms and must decide whether one histogram has a larger standard deviation than another histogram, or if the two histograms have the same standard deviation. Now, however, students are told that after completing the histogram activity, individual students will then form new groups of two and compare their answers. New pairs must reach consensus about their answers and, most importantly, *both individuals* must be able to explain what characteristics of the graphs support their answer. The instructor will then randomly select one individual from the new pairs to explain their answer for a given problem.

The cooperative structure described above builds on *social interdependence theory* (Deutsch, 1949, 1962; Johnson & Johnson, 1989, 2005), the basic premise of which is that the way in which interdependence is structured moderates how individuals interact which, in turn, determines outcomes. Cooperative goal structures result in promotive interaction (such as mutual help, sharing resources and information, acting in trustworthy and trusting ways), competitive goal structures result in oppositional interaction (such as obstructing of each other's goal achievement efforts, hiding resources and information from each other, acting in distrustful and distrusting ways), and the absence of goal structures results in the absence of interaction. The basic model proposed by social interdependence theory may be represented as follows:

Goal Structures (Interdependence) → Interaction patterns → Situational outcomes.

What is different about the cooperatively structured histogram activity? When individuals perceive that they can reach their goals if and only if the other individuals with whom they are cooperatively linked also reach their goals, social interdependence theory predicts that individuals tend to seek outcomes that are beneficial to all those with whom they are cooperatively linked. Thus, in the histogram activity, individuals know that, after working together, they must individually present their answers to another student. Students also know that, after reaching consensus with their second partner, they may be individually required to justify their answer to the instructor. In short, successful completion of the cooperative histogram activity requires both *individual and* group efforts. It is in this way that cooperative goal structures tend to result in promotive interaction while competitive and individualistic goal structures result in oppositional or no interaction respectively. Readers interested in the empirical support of social interdependence theory are referred to several meta-analyses (e.g., Johnson & Johnson, 1989; Johnson, Johnson, Maruyama, Nelson, & Skon, 1981; Roseth, Johnson, & Johnson, in press). Readers are also referred to related meta-analyses on cooperative effects, albeit from slightly different theoretical orientations (e.g., Ginsberg-Block, Rohrbeck, & Fantuzzo, 2006; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Slavin, 1980, 1983, 1995).

From a cooperative learning perspective, *any* activity may be motivating and interesting if cooperative structures link students' goals, behavior, and outcomes. In this paper we use *cooperative learning* as an umbrella term for all forms of peer learning in which students work together to maximize their own and each other's learning (Johnson, Johnson, & Holubec, 1998). Thus, by cooperative learning we also include collaborative learning, peer tutoring, cross-age tutoring, and other teaching strategies aimed at structuring the way students interact with each other as they learn. For excellent reviews of these methods see O'Donnell (2006), Boud, Cohen, and Sampson (2001), and Falchikov (2001). And, for research focusing on cooperative learning in statistics education, see Chick and Watson (2002), Courtney, Courtney, and Nicholson (1994), Giraud (1997), Keeler and Steinhorst (1995), Magel (1998), Perkins and Saris (2001), and Potthast, (1999).

2.2 Implementing Cooperative Learning

The following sections highlight materials and provide practical tips for effectively using cooperative learning in the statistics classroom. These recommendations are meant to address common concerns about using group work, some of which make instructors reluctant to adopt more student-centered methods or, alternatively, to stop using them after initial difficulties. Our hope is to provide practitioners with the tools and understanding needed to capitalize on the benefits of cooperative learning.

We begin by providing a general introduction to the steps typically involved in a cooperative lesson. We then provide examples of how these methods may be used in the statistics classroom, focusing especially on the use of cooperative learning assessment procedures. We emphasize three statistics activities that are also part of a cooperative learning module available online at the Consortium for the Advancement of Undergraduate Statistics Education, CAUSE (see http://serc.carleton.edu/sp/cause/cooperative/example.html).

Conducting a cooperative lesson typically involves four steps: (a) making pre-instructional decisions about the lesson, (b) explaining the task and cooperative structure to students, (c) monitoring and, if necessary, intervening with each learning group, and after the lesson, (d) processing and evaluating student achievement (Johnson et al., 1998; see also Davis, 1993). While detailed instructions for accomplishing each of these steps is beyond the scope of this paper, we offer a few helpful hints.

Making pre-instructional decisions. Planning a lesson begins with specifying the academic objectives. In cooperative learning, it is also recommend that educators specify the social skill objectives that specify what interpersonal and small group skills are to be emphasized during the lesson. The importance of social skills cannot be overstated as, increasingly, large numbers of children, adolescents, and young adults do not possess the social skills necessary to establish and maintain positive relationships with their peers. Further, research suggests that educators must confront social norms making academic disinterest increasingly acceptable (Steinberg, Brown, & Dornbusch, 1996). Instructors must create the conditions in which students feel safe to say things like, “That’s interesting. Tell me more.” Thus, social skill objectives may enhance student participation in statistics activities.

Explaining the task and cooperative structure to students. The second and arguably most important step in a cooperative lesson is telling your students what to do and how to do it. It is here that instructors must (a) assign students to groups, (b) specify the criteria for successfully completing the activity, and (c) structure the cooperative goals linking individual students.

- Group size. Cooperative learning groups typically range in size from two to five. In general, as the size of the learning group increases, so too do the resources needed to help the group succeed (Johnson & F. Johnson, 2006). Thus, smaller groups are typically more successful than larger groups of students, especially when time is short and/or students lack the skills to work with several peers at once. Larger groups also decrease individual member’s opportunity to contribute; correspondingly, smaller groups make it more difficult for students to hide and not contribute their share of the work. Smaller groups also make it easier to identify any difficulties students may have in working together.

- Individual accountability. Instructors must be clear about the criteria by which student performance will be evaluated. Following Brophy (2004), effective criterion make goals *immediate* (here and now rather than for the distant future), *specific* ("answer all questions with no more than one mistake" rather than "do your best"), and *challenging* (i.e., difficult but reachable). For example, instead of saying "compare the two distributions with your neighbor," it is much

more effective to say: "With your neighbor, identify three similarities and three differences between the two distributions. After five minutes I will call on one student at random to share their answers with the class.

- Make positive interdependence explicit. Above all, cooperative goal structures must be made explicit. For example, when using a problem set to review for a quiz, cooperation may be structured by saying: "Each of you has two responsibilities. First, you are each responsible for learning how to solve the problems and, so doing, preparing for the quiz. Second, you are responsible for making sure that every member of your group also knows how to solve the problem. Each member of the group will receive 5 extra points on their individual quiz if all of their group members score above 85%."

Monitoring and intervening during the cooperative activity. Once an activity begins, instructors must monitor and, when necessary, intervene in students' group work. This is not the time to get a cup of coffee, as cooperative learning requires that teachers observe interaction among group members, and assesses both academic progress and the appropriate use of interpersonal and small group skills. This is also the time when a "window" to student's reasoning and thinking begins to open with student discourse providing a uniquely powerful way for educators to understand how students understand a given concept (Case, 1992).

Group processing. Finally, time should be given for students to process, reflect and evaluate what was helpful and unhelpful in completing the assignment. For example, instructors may ask students to identify at least two behaviors that were helpful to the group and at least two behaviors that would help the group perform even more effectively in the future (Davis, 1993). Not only do these discussions help to clarify whether learning objectives were achieved, they also help to reinforce classroom norms, values and behavioral expectations. Statements like, "Raise your hand if everyone in your group participated in your discussion" makes it clear that, in this classroom everyone's participation is expected and valued.

Group processing may occur at two levels. Each learning group may discuss what they accomplished or, in whole-class processing, the teacher may give the class feedback with students sharing specific examples from their own groups. For more on group processing, readers are referred to Johnson, Johnson, and Smith (1991a, 1991b), Rau and Heyl (1990), and Walvoord (1986).

2.3 Practical Tips

In this section we suggest some practical tips for statistics instructors willing to try cooperative learning in their classes.

Assigning students to groups. For brief exercises, it should not be a problem for students to work with their friends. For extended cooperative activities however, major problems may emerge from letting students assemble into groups of their own choosing (Fiechtner & Davis, 1992).

Random groups, especially for one-time projects, are easy to assemble. They can be set up before class using a roster or they can be formed spontaneously by having students count off. For example, in a group of 40 students where you want groups of four, ask students to count off from 1 to 10, repeating this four times. Then, ask that all the "1's" get together in a group, the "2's" in a second group, etc. This method works well in creating heterogeneous groups as it rearranges students who started the class sitting together.

Using base groups to check in and track preparation for class. In addition to using different, informal

learning groups to complete activities during class, students may also be assigned to a consistent base group. At the beginning of class, members of a base group can check in with each other, ask each other questions, compare notes, and discuss their preparation for class. In our own teaching, base group members also give themselves a daily rating on how well prepared for class (e.g., Did they complete the reading, homework problems, etc.?). The base group then calculates the group's average preparation rating and charts it over time. By looking at the group average fluctuate over the semester, students recognize that they are accountable to their peers and gain awareness of their study habits. Students also gain additional experience with interpreting real data.

Getting groups started on an activity. We suggest that students' first interaction with each other be structured. Never let groups suffer through the awkward silence of "getting started." Social roles inevitably take over in such instances – e.g., the "talkers" always talk, and the "quiet" students always remain quiet. Cooperative groups work best when social roles are trumped by interdependent roles and goal structures. An easy way to structure the way groups get started is to say something like, "You're probably wondering who will start? The person born closest (or farthest) from this room should begin." Using questions like this provides a quick way for students to interact personally without being too distracting or too "touchy-feely."

Importantly, "structured starts" can also be used post hoc. Anytime instructors hear silence after beginning an activity is an ideal time to say, "You're probably wondering who will go first…" Structuring the start, even after the fact, helps students begin their work as quickly and as effectively as possible.

Assigning roles to group members. Another practical tip is to assign roles to students that give them a specific task in the group. Assigning roles can help to avoid traditional social roles (e.g., female students serving as the note-taker or male students serving as the group spokesman), and they can also be used to develop thinking and reasoning skills. Following Garfield (1993) and Johnson et al. (1998), examples of such critical-thinking roles include the following:

- Summarizing out loud: A student summarizes out loud what has just been read or discussed as completely as possible and without referring to notes or the original material. Students vocalize their understanding in order to make the implicit reasoning process overt and thus open to correction and discussion.

- Seeking Accuracy: A student seeks accuracy by correcting a member's summary, adding important information he or she did not include, and pointing out the ideas or facts that were summarized incorrectly (e.g., "I'm not sure if that is right. I thought it was…").

- Seeking Elaboration: A student relates material being learned to earlier learned material and to other things they know (e.g., "This is like what we studied last week…" or, "How does this relate to…?").

- Extending Answers: A student extends other members' answers or conclusions by adding further information or implications (e.g., "Here is something else to consider…" or, "I also think that…").

- Probing Questions: A student asks questions of the group that lead to deeper understanding of synthesis (e.g., "Would it work in this situation…?", "What else makes you believe…?" or, "Would this also work…?").

Helping students build their teamwork skills. The greater the students' teamwork skills, the higher will

be the quality and quantity of their learning. Operationally, teamwork skills are defined by specifying which behaviors are and are not appropriate within learning groups. It is not enough to tell students what skills you wish to see them use during the lesson. Teachers must also explain exactly what is expected by modeling the skill in front of the class. As an example, consider what it looks and sounds like when students do not pay attention. Not paying attention often looks like slouching, reading the newspaper, completing the Sudoku, checking e-mail, sleeping, etc. Not paying attention often sounds like finger tapping, turning pages, gossiping with a peer, typing, snoring, etc. In our experience, demonstrating such behaviors can offer a moment of levity in the classroom, with humor making it "safe" for students to engage in more productive behaviors that, in other contexts, may not be socially acceptable among their peers. Practical examples of social skills that enhance critical thinking were provided above (see "assigning roles to group members").

Helping a group that is not working well together. Not every group will work well together. Students vary in their preparation, motivation, and preferences for learning. If a group does not seem to be working well together it is important to try to figure out the cause. Is one student unprepared and perhaps not willing to help? Are students sitting silently because they don't understand where to begin? The teacher can help by going to the group and asking a question or offering a prompt to get them going. If one student seems to be a problem, the teacher can invite that student into the hallway and find out what seems to be going wrong. If a student says that the rest of the group members are not contributing, or that they themselves have not prepared well, the instructor can offer advice to the student or the group, as appropriate.

Here again we emphasize that forming different, random groups for each activity can prevent the problem of some groups working consistently better than others. Simply put, random assignment ensures that individual differences in achievement, interpersonal skills and the like are evenly distributed across learning groups. Over time, these differences are also distributed across all learning groups, ensuring that – again, over time – any effects of between-group differences are minimized. Importantly, randomization of student groups also helps students to get to know as many of their classmates as possible, a key step in turning a classroom into a caring, supportive learning community. Consider the following student's comment on the introductory statistics course evaluation:

> "I have never had a professor or instructor that was this effective … I always felt valued, always … we would work in groups frequently which always helped … Big picture: he provided a unique learning environment that will help a variety of learning styles … Working in groups has made a big impact. Having built rapport with the other students quickly in the semester helped. Having a base group and assigned seating really helped not feel so lost. Having to report to what level we did our homework to our base groups, made each of us accountable and probably made each of us come to class more and do homework more. Overall, I can't compare his style to any other professor or instructor I have ever had here…"

2.4 Assessment and Cooperative Learning

Assessment provides yet another opportunity to capitalize on the effects of cooperative activities. For example, in the GIG procedure (Group preparation, Individual assessment, Group assessment; Johnson & Johnson, 2002), students first meet in their cooperative learning groups to discuss study questions and to come to consensus about the answers. The cooperative goal is to ensure that all group members understand how to answer the study questions correctly. Next, students take the assessment (e.g., quiz, test, etc.) individually, the task (obviously) being to answer each question correctly. Last, after all group members have finished the individual portion of the assessment, the group as a whole then meets again to complete the group portion of the test.

There are a myriad of ways of using the GIG procedure. As suggested earlier, extra credit may be awarded if

every member of the learning group scores above a certain threshold on the individual assessment. Other times, students may meet in their cooperative learning groups and retake the entire test, the cooperative goal being to reach consensus on the answers and to ensure that all members can explain the answer. Randomly calling on individual members of a group is, again, one way to ensure that individuals are accountable for contributing to the group goal.

In our own undergraduate statistics courses, we use a procedure whereby students complete the individual portion of a quiz at home. Individual questions emphasize statistical literacy, thus providing each student with a structured review of the material. The next day, students turn in their individual quiz and meet in cooperative learning groups to complete the group portion of the quiz. For the group portion, students are randomly assigned to groups of three, thus ensuring that different students work together during every assessment. Group quiz questions emphasize statistical reasoning and thinking, thus going beyond the individual portion of the quiz and capitalizing on the power of group discourse to realize deeper understanding of the concepts.

In our version of group assessment, every individual member of the group writes their own answers to each question. Students are told that one, randomly chosen member of each group will have their quiz graded, and that their score will be given to the group as a whole. Thus, we structure the sink-or-swim requirement, with the cooperative goal of getting the best possible grade encouraging discourse, helping, and individual accountability. Group members also review each other's quiz answers until every member is satisfied with each other's answers. If students cannot agree on an answer, instructors intervene and/or encourage them to compare their answer with an adjacent group. As in other cooperative activities, these assessments serve as windows to students' reasoning and thinking. The group quizzes also reinforce and deepen students' understanding of the course's more complex topics. It is our experience that an incredible amount of learning occurs during these group assessments, with students often leaving class smiling and saying, "I really understand this now!"

2.5 Online Materials for Statistics Educators

While many activities can be easily structured to facilitate cooperative learning, we highlight three statistics activities that are already structured for cooperative learning. They are available online at the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE; see http://serc.carleton.edu/sp/cause/cooperative/example.html).

- Body Measures: Exploring Distributions and Graphs - Using cooperative learning methods, this lesson introduces distributions for univariate data, emphasizing how distributions help us visualize central tendencies and variability. Students collect real data on head circumference and hand span, then describe the distributions in terms of shape, center, and spread. The lesson moves from informal to more technically appropriate descriptions of distributions.

- Histogram Sorting - Using cooperative learning methods, this activity provides students with 24 histograms representing distributions with differing shapes and characteristics. By sorting the histograms into piles that seem to go together, and by describing those piles, students develop awareness of the different versions of particular shapes (e.g., different types of skewed distributions, or different types of normal distributions), and that not all histograms are easy to classify. Students also learn that there is a difference between models (normal, uniform) and characteristics (skewness, symmetry, etc.).

- Understanding the standard deviation: What makes it larger or smaller? - Using cooperative learning methods, this activity helps students develop a better intuitive understanding of what is meant by variability in statistics. Emphasis is placed on the standard deviation as a measure of variability. This lesson also helps students to discover that the standard deviation is a measure of the density of values about the mean of a distribution. As such, students become more aware of how clusters, gaps, and extreme values affect the standard deviation.

2.6 Summary of Collaborative Learning in Statistics Courses

To summarize, this paper's first section emphasized that the purpose of cooperative learning is to improve the learning of every individual student. Using these methods, students learn statistics in ways that not only enhance their statistical reasoning and communication skills, but also give them practice in working collaboratively, which models the collaborative nature of real statistical work. Cooperative learning groups also enhance critical thinking, conceptual understanding, and other higher order skills.

The point was also made that group work does not necessarily constitute *cooperative* group work. Thus, statistics educators must understand the theoretical underpinnings of these methods and become experienced through practicing this method. An important way to support instructors in this process is through collaborative teaching groups. Indeed, it is our belief that successfully using cooperative learning depends, at least in part, on successful collaboration among statistics educators.

3. Collaboration in Teaching Statistics

While cooperative learning has been widely promoted for use in the classroom, it has been much less visible as a method of faculty development and instructional change. The same authors who have widely disseminated research on the positive effects of collaboration in student learning, state that "the research that validates the use of cooperative learning in the classroom also validates the use of cooperative faculty teams at the department or college level" (Johnson, Johnson, & Smith, 1991a, p. 115). These authors note that most faculty are not used to, nor skilled in working in groups with their peers. However, the use of cooperative faculty groups can be a powerful way to bring about needed changes in teaching and curriculum, such as those recommended in the GAISE guidelines (Franklin & Garfield, 2006).

Most people who teach statistics (and this is also true in other disciplines) do so in relative isolation, even if they have colleagues who also teach statistics. What we do in our classrooms is often known only by us and by our students. Academic freedom allows many college faculty to develop and teach courses without any collaboration with other colleagues, and rarely do we have our colleagues attend our classes to see how we are teaching. We propose a distinct alternative to this approach of teaching of statistics in isolation. Building again on the premise that statistics education ought to resemble statistical practice, we argue for forming a collaborative teaching group with other faculty, either at the same school or at comparable schools, to discuss and share teaching experiences and ideas and to provide support with teaching challenges.

In the only published article devoted to this topic, Rumsey (1998) described cooperative teaching of statistics as "an environment where teachers share ideas and experiences, support each other, and work together toward a common goal of quality teaching. Individual accountability is reflected by the performance and effectiveness of each instructor." The following section builds on this sole article as well as the general literature on cooperative teaching.

3.1 What Collaboration in Teaching Provides

We see six main reasons why forming a collaborative teaching group can help us become better teachers of statistics. First, when we collaborate with other teachers, we can accomplish more and at a higher level than working alone (Rumsey, 1998). For example, we can produce better instructional materials, assessments, and teaching techniques by building on the diverse backgrounds and experiences of the teachers in the group. Second, collaboration promotes reflection on our teaching by verbalizing and justifying what we believe and practice, which also leads us to question our beliefs and practices. Third, collaboration can motivate and support us in making changes that may be daunting to try on our own. It can provide a supportive environment to reflect on these changes and move forward, rather than abandoning efforts when they are not immediately successful. Fourth, collaboration provides a mechanism to develop and maintain a level of consistency from section to section within the same course. For example, collaboratively developing and using a common syllabus, teaching materials and assessment materials facilitates consistency. Developing these materials as a group also encourages

discussion about what is important for students to learn, thus ensuring a tighter link between instructional objectives, curriculum, and assessment. Fifth, collaboration provides a sense of community: Working together towards a mutual goal also results in emotional bonding where group members develop positive feelings towards the group and commitment towards working together. Rumsey (1998) notes that discussions and group decision making about teaching, testing and grading, as well as soliciting and providing feedback to peers, creates an atmosphere of teamwork and community that can improve and enhance our work environment and our job satisfaction. Finally, sixth, collaboration provides support and guidance for new teachers: New instructors can benefit from the support, ensuring a more positive beginning to their career as statistics educators.

3.2 The Role of Collaborative Teaching in Supporting Innovation and Change

Importantly, cooperative teaching groups provide support for a teacher trying to move from a lecture style of teaching to a more active learning approach. Such support is essential, especially a teacher who has felt comfortable lecturing and is not initially comfortable in a student-centered classroom. Colleagues can offer tips, advice and empathy while supporting their peer in making this difficult change. This may prevent the instructor from saying (as we have heard others say), "I have tried cooperative groups but it didn't work for me so I am going back to the lecture method I'm used to."

It is important to note that beginning a collaborative teaching group takes commitment. Rumsey (1998) also points out that the main disadvantage of cooperative teaching is that it demands time, and in fact may require a large initial time commitment. However she also points out that once the group is established and new materials and methods are in place, the individual time commitment diminishes and takes on more of a maintenance role. She also notes that any attempt to make changes in teaching requires a large amount of effort on the part of the instructor, but that a collaborative teaching group can minimize the amount of effort needed.

3.3 How Does a Collaborative Teaching Group Work?

Garfield and Ben-Zvi (in press) provide six examples of different types of collaborative teaching groups. Four are structured around specific courses at a single institution and two are more informal and include faculty from multiple institutions. Rumsey (1998) also describes the example of weekly teaching meetings of a faculty member and graduate teaching assistants at one institution. The primary goals were to offer a forum to discuss and present ways to teach the concepts to undergraduate students and to provide a testing ground for new ideas. Each meeting included an overview of the material for the upcoming week (based on a common syllabus). Positive results were reported about the use of cooperative teaching in helping the department move to a more "general education" approach to teaching statistics than a traditional, more mathematical approach.

Quality management ideas and teamwork were described by Wild (2006) to implement systems to deliver continual improvement in Auckland University's large, first-year courses serving over 3500 students per year. There has been recognition of the team's success in the form of several university teaching awards and a national teaching excellence award. Amazingly, the team members also find time for other cooperative activities such as being involved in the development of the national curriculum for statistics in schools and running nation-wide outreach activities like the New Zealand Census At School project and teacher workshops.

A third example of cooperative teaching is in the department of Educational Psychology at the University of Minnesota. Collaborative teams of faculty and graduate students were used to completely redesign introductory undergraduate and graduate courses, to teach them in a consistent way, and to provide mentoring and supervision of beginning teachers. This program recently won an award from the American Psychological Association for its innovative program for training graduate students to become excellent teachers of statistics.

Another version of collaborative teaching is the Japanese Lesson Study approach, where teams of teachers meet to develop, implement, and evaluate an innovative lesson. See Roback, Chance, Legler and Moore, (2006) and Garfield, delMas and Chance (in press) for more information on how to adapt Japanese Lesson Study to the teaching of college statistics courses.

A final example is a group called "Stat Chat," an informal group of more than a dozen statistics educators (see www.macalester.edu/~kaplan/statchat/index.html). Meeting monthly, colleagues makes presentations to each other on interesting projects, debate and discussions issues of pedagogy, and also share data sets and activities.

3.4 How to Start a Collaborative Teaching Group

Cooperative activity among faculty should be as carefully structured as is cooperative interactions among students in classrooms (Johnson et al., 1991b). Johnson and colleagues provide many practical suggestions for what they term "Collegial Support Groups," suggesting that three key activities are particularly important. First, collegial support groups offer frequent, and regular professional discussions about student learning. Second, they allow for the discussion, planning, and development of curriculum materials. And, third, they provide ways for instructors to teach together and/or to observe each other teach. These authors also discuss how such a group can provide support and leadership in implementing cooperative learning strategies in one's classes, an experience that can be challenging and difficult for many instructors used to teaching in more traditional, teacher-centered formats.

Based on her experience at Kansas State, Rumsey (1998) offers some practical tips for forming and using a cooperative teaching group to promote instructional change: These include creating an agreed upon structure, being clear and realistic about expectations of group members, being flexible and creative while at the same time, being organized, and offering support and guidance in a structured environment. Weekly teaching meetings help greatly in this regard.

We think that there are many ways to start such a group. For example, a faculty member may start a group by requiring that graduate teaching assistants participate. It is also possible to start such a group with faculty colleagues and invite interested students to join. It helps to have one person who is willing to schedule and run the meetings and coordinate the group, although tasks can often be divided among, and selected by, group members. We encourage members of the group to observe each other's classes to see how the same lesson can be taught. It is very illuminating to then compare the different outcomes of the same lesson taught by two different instructors in two different settings.

To summarize, despite there being little written about collaborative teaching of statistics, the general literature on teaching and learning supports these practices (see, for example, "communities of practice" (see footnote) by Lave and Wenger (1991) and Garfield and Ben-Zvi (in press)). We strongly encourage more publications of this topic along with research studies on the use of collaborative teaching in statistics.

3.5 Summary

The social psychologist Kurt Lewin is credited with saying that "the way to change individuals is by changing groups" (D. Johnson, personal communication, December 14, 2006). Johnson, an international expert on cooperation, sees collaborative teaching groups as a method to engender real and sustained changes in teaching. He also suggested that such a group can serve as a way for novice teachers to become aware of and comfortable using approaches to teaching that are different than their own training. Consider a new PhD in statistics who has only experienced traditional methods of teaching and is now at an institution where active learning is encouraged. Never having experienced active learning, this person may be reluctant to try something other than lectures. A collaborative teaching group can help the new teacher by sharing experiences, inviting the person to see their classes, and providing guidance and support. By working collaboratively, statistics educators can also help lead and support each other in moving to a more student-centered instruction. To this end, we end this paper with a plea for statistics educators to build on the collaborative foundations of statistical work by trying one or more of these methods in the coming year.

Footnote

The concept of a *community of practice* (often abbreviated as CoP) refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate over an extended period

to share ideas, find solutions, and build innovations.

References

Boud, D., Cohen, R., & Sampson, J. (2001). *Peer learning in higher education: Learning from and with each other*, (pp. 1-17). London: Kogan Page.

Brophy, J. (2004). *Motivating students to learn, (2nd ed.).* Mahwah, NJ: Lawrence Erlbaum

Case, R. (1992). *The mind's staircase: Exploring the conceptual underpinnings of children's thought and knowledge.* Mahwah, NJ: Lawrence Erlbaum.

Chick, H. L., & Watson, J. M. (2002). Collaborative influences on emergent statistical thinking – a case study. *Journal of Mathematical Behavior, 21,* 371-400.

Courtney, D. P., Courtney, M., & Nicholson, C. (1994). The effect of cooperative learning as an instructional practice at the college level. *College Student Journal, 28,* 471-477.

Davis, B. (1993). *Tools for teaching.* Jossey-Bass Publishers: San Francisco.

Deutsch, M. (1949). A theory of cooperation and competition. *Human Relations, 2,* 129-151.

Deutsch, M. (1962). Cooperation and trust: Some theoretical notes. In M. Jones (Ed.), *Nebraska symposium on motivation*. Lincoln: University of Nebraska Press.

Falchikov, N. (2001). *Learning together: Peer tutoring in higher education.* London: Routledge Falmer.

Fiechtner, S. B., & Davis, E. A. (1992). Why some groups fail: A survey of students' experiences with learning groups. In A. Goodsell, M. Maher, V. Tinto, and Associates (Eds.), *Collaborative learning: A sourcebook for higher education.* University Park: National Center on Postsecondary Teaching, Learning, and Assessment, Pennsylvania State University.

Franklin, C., & Garfield, J. B. (2006). The GAISE Project: Developing statistics education guidelines for pre K-12 and college courses. In G. Burrill (Ed.), *Thinking and reasoning with data and chance: 2006 NCTM yearbook* (pp.435-375). Reston, VA: National Council of Teachers of Mathematics.

Garfield, J. B. (1993, July). Teaching statistics using small-group cooperative learning. *Journal of Statistics Education*, *1*(1). Retrieved December 30, 2006, from http://www.amstat.org/publications/jse/v1n1/Garfield.html

Garfield, J. B., & Ben-Zvi, D. (in press). *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*. Emeryville, CA: Key College Publishing.

Garfield, J. B., delMas, R., & Chance, B. (in press). Using students' informal notions of variability to develop an understanding of formal measures of variability. In M. Lovett & P. Shah (Eds.), *Thinking with Data*. Mahwah, NJ: Lawrence Erlbaum Associates.

Ginsburg-Block, M. D., Rohrbeck, C. A., & Fantuzzo, J. W. (2006). A meta-analytic review of social, self-concept, and behavioral outcomes of peer-assisted learning. *Journal of Educational Psychology, 98,* 732-749.

Giraud, G. (1997, November). Cooperative learning and statistics instruction. *Journal of Statistics Education 5*(3). Retrieved December 30, 2006, from: http://www.amstat.org/publications/jse/v5n3/giraud.html

Hogg, R. V. (1992). Towards lean and lively courses in statistics. In F. Gordon, & S. Gordon (Eds.), *Statistics for the twenty-first century* (pp. 3-13). Washington, DC: Mathematical Association of America.

Johnson, D. W., & Johnson, F.P. (2006). *Joining together: Group theory and group skills, (9th ed.).* Boston: Allyn & Bacon.

Johnson, D. W., & Johnson, R. T. (2005). New developments in social interdependence theory. *Genetic, Social, and General Psychology Monographs, 131,* 285 – 358.

Johnson, D. W., & Johnson, R.T. (1989). *Cooperation and competition: Theory and research.* Edina, MN: Interaction Book Company.

Johnson, D. W., & Johnson, R.T. (2002). *Meaningful assessment: A manageable and cooperative process.* Boston, MA: Allyn & Bacon.

Johnson, D. W., & Johnson, R.T. & Holubec, E. (1998). *Cooperation in the classroom* (6th ed.). Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T. & Smith, K. (1991a). *Cooperative learning: Increasing college faculty instructional productivity*. ASHE-ERIC Higher Education Report, No. 4, Washington DC, The George Washington University School of Education and Human Development.

Johnson, D. W., Johnson, R. T., & Smith, K. (1991b). *Active learning: cooperation in the College Classroom*. Edina, MN: Interaction Book Company.

Johnson, D. W., Maruyama, G., Johnson, R. T., Nelson, D., & Skon, L. (1981). The effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Bulletin, 89,* 47-62.

Keeler, C. M., & Steinhorst, R. K. (1995, July). Using small groups to promote active learning in the introductory statistics course: A report from the field. *Journal of Statistics Education*, *3*(2). Retrieved December 30, 2006, from http://www.amstat.org/publications/jse/v3n2/keeler.html

Kohn, A. (1986). *No contest: The case against competition.* Boston: Houghton Mifflin.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: University of Cambridge Press.

Lovett, M. C., & Greenhouse, J. B. (2002) Applying cognitive theory to statistics instruction. *The American Statistician*, *54*(3), 196-206.

Magel, R. C. (1998, November). Using cooperative learning in a large introductory statistics class. *Journal of Statistics Education*, *6*(3). Retrieved December 30, 2006, from: http://www.amstat.org/publications/jse/v6n3/magel.html

O'Donnell, A. M. (2006). The role of peers and group learning. In P.A. Alexander & P.H. Winne (Eds.), *Handbook of educational psychology (2nd Ed.)* (pp. 781-802). Mahwah, NJ: Lawrence Erlbaum Associates.

Osvaldo Fabbroni, E., Chang Lee, J., Lievesley, D., Martin-Guzman, P., Morettin, P. A., & Rossman, A. (2007, July). *The challenges for cooperation in statistics education.* Panel discussion at the 7th International Conference on Teaching Statistics, Salvador, Bahia, Brazil.

Perkins, D. V., & Saris, R. N. (2001). A "jigsaw classroom" technique for undergraduate statistics courses. *Teaching of Psychology, 28,* 111-113.

Potthast, M. J. (1999). Outcomes of using small-group cooperative learning experiences in introductory statistics courses. *College Student Journal, 33,* 34-42.

Rau, W., & Heyl, B. (1990). Humanizing the college classroom: Collaborative learning and social organization among students. *Teaching Sociology, 18,* 141-155.

Roback, P., Chance, B., Legler, J., & Moore, T. (2006, July). Applying Japanese lesson study principles to an upper-level undergraduate statistics course. *Journal of Statistics Education, 14*(2). Retrieved December 28, 2006, from http://www.amstat.org/publications/jse/v14n2/roback.html

Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003). Peer-assisted learning interventions with elementary school students: A meta-analytic review. *Journal of Educational Psychology, 95,* 240-257.

Roseth, C. J, Johnson, D. W., & Johnson, R. T. (in press). Promoting achievement and social goals: A meta-analysis of cooperative, competitive, and individualistic goal structures.

Rumsey, D. J. (1998). A cooperative teaching approach to introductory statistics. *Journal of Statistics Education*, *6*(1). Retrieved December 28, 2006, from http://www.amstat.org/publications/jse/v6n1/rumsey.html

Slavin, R. E. (1980). Cooperative learning. *Review of Educational Research, 50,* 315-342.

Slavin, R. E. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin, 94,* 429-445.

Slavin, R. E. (1995). *Cooperative learning (2nd Ed.).* Boston: Allyn & Bacon.

Steinberg, L., Brown, B., & Dornbusch, S. (1996). *Beyond the classroom: Why school reform has failed and what parents need to do*. New York: Simon and Schuster.

Walvoord, B. F. (1986). *Helping students write well: A guide for teachers in all disciplines.* (2nd ed.) New York: Modern Language Association.

Wild, C. (2006). On cooperation and competition. In A. Rossman & B. Chance (Eds.), Proceedings of the seventh international conference on the teaching of statistics (ICOTS-7), Salvador, Bahia, Brazil, [CD-ROM]. Voorburg, The Netherlands: International Statistical Institute. Retrieved April 28, 2008, from http://www.stat.auckland.ac.nz/~iase/publications/17/PL7_WILD.pdf

---

Cary J. Roseth, PhD
Michigan State University
513C Erickson Hall
East Lansing, MI 48824-1034
U.S.A.
croseth@msu.edu

Joan B. Garfield, PhD
University of Minnesota
315 Burton Hall, 178 Pillsbury Drive SE
Minneapolis, MN, 55455-0208
jbg@umn.edu

Dani Ben-Zvi, PhD
University of Haifa
Mt. Carmel
Haifa, Israel
dbenzvi@univ.haifa.ac.il
