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AUTHOR Dunn, Dana S.
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ABSTRACT

Students should not learn statistical concepts in isolation; statistics and data analysis invite conversations concerning which analysis to use and why, what was found and why, and what results mean and why. To emphasize the importance of this learning in common, a college teacher requires students to collaborate on research projects from hypothesis conception to empirical realization, from data collection to analysis, interpretation, write-up, and presentation. Collaborative efforts provide a practical division of labor and necessarily promote recursive learning, as collaborators must explain and justify their choices to one another. Learning statistics in common encourages students to clarify the choice, application, and appropriateness of statistical analyses; to share and defend a data analytic point of view; to learn while critiquing the perspective of another; to cooperate to create a finished project (manuscript or talk); and to mimic professional psychologists who often work on joint research projects. (Author/SLD)

Two Heads are Better Than One: Learning Statistics in Common

Dana S. Dunn

Moravian College

Students should not learn statistical concepts in isolation: Statistics and data analysis invite conversations concerning which analysis to use and why, what was found and why, and what results mean and why. To emphasize the importance of this learning in common, I require students to collaborate on research projects from hypothesis conception to empirical realization, from data collection to analysis, interpretation, write-up, and presentation. Collaborative efforts provide a practical division of labor and necessarily promote recursive learning—collaborators must explain and justify their choices to one another. Learning statistics in common encourages students to clarify the choice, application, and appropriateness of statistical analyses; to share and defend a data analytic point of view; to learn from while critiquing the perspective of another; to cooperate to create a finished project (e.g., manuscript, talk); and to mimic professional psychologists who often work on joint research projects.

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One of the problems plaguing the traditional teaching of statistics is that students learn quantitative concepts in relative isolation from one another. That is, they read their texts, do their homework, and attend lectures where calculation procedures are reviewed, but little interaction about the material actually takes place. It's as if what is learned now is being saved for some future use. Students have few opportunities to discuss statistics and data analysis, rather, they pick up some knowledge that will (hopefully) be used sometime in the future, say, in another psychology course, possibly in a research project, or when reading the newspaper or some technical report.

Students do not typically have the change to engage in conversations about which analysis to use and why, why one statistical test is more appropriate for answering a question than another and why, what results were found and why, and what the results mean (statistically and in plain—preferably written—English) and why. To be sure, it is possible to create situations during class time where students can ask questions, review research results, and discuss methodology, all with an eye to statistics and data analysis issues.

Wherever possible, however, I prefer to create situations where I do not always play the role of teacher, instructor, or expert, so that my students are not put in so passive a position (asking questions, obtaining answers from me, and then dutifully jotting down notes). Instead, I prefer to allow students to collaborate with one another, to work together on joint projects or exercises, both in and out of the classroom. They still ask questions, of course, but these tend to be more informed than elementary, and they are often thought through.

Collaborative efforts provide a practical *division of labor* and necessarily promote *recursive learning*. Students must each take responsibility for doing activities that move the project along; they must share that responsibility; and they must constantly review their progress, compare ideas, and discuss choices. Collaborators must also necessarily explain and justify their choices to one another. In doing so, each partner (I prefer to keep groups small—two, occasionally three, collaborators) must outline his or her logic about the choice of statistical analysis or analyses. Once a procedure is chosen, the other partner must agree about its appropriateness to the research design and data, and then help with the actual application and calculations.

Thus, learning statistics in common can encourage students to:

- clarify the choice, application, and appropriateness of a statistical analysis
- to share and defend a data analytic point of view

- to learn from while critiquing the ideas of a collaborator
- to cooperate to create a finished project (e.g., manuscript, talk, lab report)
- to mimic professional psychologist who often work collaborative on research (science is, after all, a collaborative or shared enterprise—few research efforts in psychology are solo ventures)

Some Possible Collaborative Activities

Pairs of student partners can collaborate on:

Critiquing a published piece of research collaboratively, possibly redesigning the work or extending it in new directions. Students can select a topic (or one can be assigned), do a literature search, select a representative paper, read it independently, and then critique it together. The critique can be oral and then written, for example, but the main point is to get the students to learn to work together. Besides critiquing the work, they can also offer other possible analyses, redesign the methods (and therefore the analyses), or take the research ideas in new directions.

Writing a joint research proposal or *prospectus.* Here the students identify a research question, search the lit, design a study, write a proposal—one where heavy emphasis is placed on research design coupled with planned statistical analysis. (Basically, the students write an APA style paper composed of Abstract, intro, method, and proposed Results (intended analyses and findings), and References.

Doing an in-class lab and co-authoring a lab report about it. Students collect data and analyze it together, and the write a lab report jointly. (An alternative to all these activities, of course, is to have students do everything together except the final write-up—I have done this and it works well, but I prefer to have students learn from each other even on the last component of the exercise, as it usually leads to better written and more coherent papers).

Designing and conducting a collaborative experiment from start to finish. Student collaborators are responsible for everything—from soup to nuts—in the conception, design, data collection, analysis and interpretation, and write-up of a project. A long period of time—at least half a semester, preferably more—is needed to do this well.

Coauthoring an APA style manuscript or an oral presentation ("talk"). The data may be "canned" or collected, but the emphasis is placed on the careful presentation of statistical results (as well as the rest of the paper) and their interpretation in written form or when presented in front of a group (say, classmates).

Making Collaboration a Success

Define responsibilities of collaborators clearly. Students are used to working alone and paying the consequences when they fail to meet course expectations. When

collaborating, they must clearly understand that they are responsible for their own work (grades) as well as that of any partner. If both collaborators are to receive the same grade on a project, then they need to understand that fact at the outset.

Collaborators must understand the idea behind a shared division of labor. Collaborators do not necessarily have to do everything together, though they must discuss everything. An important point is ensuring that they share all ideas about statistical analysis; if one performs the initial statistical analysis, for example, then the other must (separately) check the work and verify its accuracy.

Consider having collaborators develop a research contract. Students draft a relatively detailed agreement of their mutual research responsibilities to their partnership, sign it, and share it with the instructor (who retains a copy in case the contractual obligations are not entirely met; see Dunn, 1999). Such contracts outline all the responsibilities and expectations, eliminating annoying surprises and misinterpretations along the way.

Ask for private reports on how a collaboration is going with some frequency (use evaluation forms or private journals). Students can fill out some short evaluation form with rating scales every so often. Alternatively, I've asked students to keep a research journal that I collect, read, and grade at relatively regular intervals. This private journal is one method allowing an instructor to gauge whether one person is doing the lion's share of the work while the other is getting a free ride. Checking on the collaboration ensures that no student feels that he or she is being taken advantage of by a reluctant (or lazy) partner, and that all students realize the need to keep up on their work because it will be checked by an interested third party (the instructor).

Start with a simpler collaborative effort (paper critique) before moving to more complex activities (conducting a project, writing a joint paper). Jumping into a big collaborative project is not always a good idea—beginning with a smaller project or two, building a collaborative relationship gradually may make a great deal more sense.

Switch off partner responsibility on each project (i.e., one serves as PI on one project, the other as co-PI; vice-versa for the next one). One way to encourage each partner to work hard is to switch responsibility roles, a technique colleagues at Washington and Lee University use. If more than one collaborative effort is being conducted, then one member of the pair takes primary responsibility on one project—the other takes it on the next one, and so on.

Peer Review: Collaborators Comment on Other Collaborations

Once a pattern of collaboration is established between a pair of partners, the circle can be widened. Peers comment on the work of peers, often sharing insights gained from their own collaborative experiences.

Critiquing collaborative research ideas. In a class setting, each collaborative partnership can offer ideas that are open to comment from other groups.

Critiquing collaborative research designs. In a class setting, each collaborative partnership can present preliminary research designs that are open to constructive ideas from other partnerships.

Reviewing the analysis and interpretation of statistical results. In a class setting, a collaborative pair shares their main results, analyses, and interpretations with other groups. Such feedback can help peers to consider alternative hypotheses and interpretations for results, and also refine research conclusions before a final summary, such as a paper or a presentation, is undertaken.

Reviewing draft APA manuscripts summarizing student research. (In-depth example) My statistics and research methods classes always have a writing workshop. At least one class day (occasionally more) is set aside to share and read rough drafts. Two collaborators can comment on the work of another partnership, while receiving comments on their own work. I often have pairs of students read the rough draft project papers of other partnerships—each partnership reads and then constructively critiques the work of another partnership (or more than one, as I often take an entire class to have rough drafts passed around the room). Besides having students read each other's papers, I also try to give each draft manuscript a quick read, writing down comments, suggestions, and corrections as I go. A happy result of this writing workshop is not only that students effectively teach while learning from one another—it is also true that the final, submitted papers I receive are of higher quality and usually much easier to grade. That is, I actually get to read for and grade on issues of argument, content, and style, as there are few (if any) grammatical problems or major errors where APA style is concerned.

Having experienced the responsibilities and benefits of collaboration with one partner helps students to be more open minded about the nature of the critiques they receive from others. Collaboration reduces the common defensiveness or doubt often associated with many peer review activities. Collaboration enables students to be more open about offering comments and criticisms, just as the process of reading the work of others introduces another form of recursion (extending what they learned to the work of others).

In simple peer terms, of course, every paper usually gets read by a minimum of three "reviewers"—at least two partners representing another group, and me, the instructor. Generally, most papers are read by 5 or 6 people. Such peer commentary and support makes polishing or completing a final draft much easier than it might be otherwise.

Conclusion

Collaboration in statistics courses is a straightforward way to promote active learning that reinforces course content. Students also benefit from the opportunity to

work with and learn from a partner(s), while actively using course material. Instructors benefit because they know that some focused application of course material is taking place outside of the classroom, that the teaching of important statistical concepts is being carried out in a novel and helpful way. Where learning to actually use statistics is concerned, two heads are definitely better than one.

Author Notes

This presentation is part of a symposium—Teaching statistics: Active learning strategies for engaging students—given on August 24, 2001 at the 2001 Annual Meeting of the American Psychological Association, San Francisco. The other symposium presenters were Dr. Barney Beins (Ithaca College) and Dr. A. T. Panter (University of North Carolina, Chapel Hill).

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Questions or comments concerning this presentation can be addressed to Dana S. Dunn, Department of Psychology, Moravian College, 1200 Main Street, Bethlehem, PA 18018-6650; e-mail: dunn@moravian.edu.

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