Activities for Student Engagement in a Statistics Course

Tracy Zinn and Whitney Smiley

James Madison University

Many psychologists have written about students' apprehension for statistics (e.g., Baloglu, 2003). Others, including the authors of *Statistics Without Tears* (Rowntree, 2004) and *Statistics for the Terrified* (Kranzler, 2007), have even attempted to address students' fears in their textbooks. There is good reason for this concern: Students who are anxious about or who have little faith in their ability to do math typically perform worse in statistics courses (Adams & Holcomb, 1986; Zeider, 1991). Thus, students' fears remain an issue for many statistics instructors.

Actively engaging students in the material is one manner of addressing this issue, and there are numerous ways of incorporating "activity" into a statistics class. Below, we discuss several activities used in a psychological statistics course, including (a) using applets for demonstrations, (b) incorporating current news articles pertaining to psychology, and (c) a data collection project.

Computer Demonstrations and Applets

Many statistics textbooks now come with online applets or other activities that students can use to gain a better understanding of statistical concepts. For example, McClelland's (1999) *Seeing Statistics* is a series of applets that teaches concepts such as variability, hypothesis testing, power, and regression. Using these applets, students can see a visual representation of the concepts covered in their textbooks. They do not have to rely on the technical or artistic skill of the instructor.

News Articles in Psychology

One of the primary difficulties in teaching statistics is helping students see the relation between the technical knowledge they need to learn and the bigger picture in psychology—in other words, why they should be interested in this technical knowledge. One way in which we attempt to teach this relation is by discussing news articles related to psychology at the beginning of each class. For example, if we are talking about correlation, we will present a popular press article about a psychological study that used correlational methods. This serves two purposes. First, we can show students how the concepts they are learning in class relate to psychological research that might be of interest to them. Second, it is an opportunity to highlight differences in how the media and researchers present the same findings. By integrating popular press articles pertaining to statistics, we can help build students' critical thinking skills. Finally, we often add assignments throughout the term where students bring in articles from the media that touch on psychology, and students can explain what types of statistics would be appropriate to use to analyze those data. Students report that they appreciate the connection between what they are learning and what they hope to do as a profession.

Data Collection Project

We group students into pairs based on their reported interests and then ask them to collect and analyze data. In their pairs, students identify two variables, such as amount of exercise and self-esteem, and then either construct questionnaires to measure those variables or incorporate existing measures into their studies (we ask that students avoid questions about underage drinking, drug use, or other possibly illegal activities.) Students also collect limited demographic data (e.g., gender, GPA) so they can run at least two different statistical analyses on their data set. The students then anonymously answer the surveys for their classmates. With this project, students learn about survey construction and administration; collecting, entering data, and analyzing data; and writing up their results. Often students report that this project is their favorite part of the course because they can see an application of the methods they are studying.

Approaches for Structuring the Statistics Course

Hypothesis Testing

Describes a freely available online tutorial that teaches hypothesis-testing concepts. The instructor assigned one section of psychological statistics

students to complete an online hypothesis-testing tutorial that included a packet of information about the tutorial, an assignment, and a follow-up quiz. The other section received the regular assignment and the same follow-up quiz. Students in the tutorial condition performed better on a quiz than students in the control condition.

- Aberson, C. L., Berger, D. E., Healy, M. R., & Romero, V. L. (2003). Evaluation of an interactive tutorial for teaching hypothesis testing concepts. *Teaching of Psychology, 30,* 75-78.

Just-in-Time Teaching

Describes a web-based teaching strategy known as Just in Time Teaching (JiTT). The authors compared JiTT to lecture in two sections of an undergraduate statistics course. Students in the lecture group took a five-item, in-class quiz over reading assignments prior to hearing lectures over the material. Students in the JiTT condition completed sets of questions on the Internet before class. The instructor then discussed students' answers to the questions in class. The JiTT group scored significantly higher than the control condition on the final exam.

- Benedict, J. O., & Anderton, J. B. (2004). Applying the Just-in-Time Teaching approach to teaching statistics. *Teaching of Psychology, 31,* 197-199.

ESTAT Software

Describes the use of ESTAT software to help teach psychological statistics. This software requires students to "eyeball" data and analyze statistical output. For example, the computer might give a diagram of a data set and ask students to estimate the mean and standard deviation. Then the software gives the actual estimates and shows students how close they were to the actual estimates. The article describes two different activities in which ESTAT was helpful as a review. Students reported that the software was engaging and interesting and recommended its use in future courses.

- Britt, M. A., Sellinger, J. & Stillerman, L. M. (2002) A review of ESTAT: An innovative program for teaching statistics. *Teaching of Psychology, 29,* 73-75.

Generating Practice Problems

Describes the use of student-generated word problems to teach statistical concepts. First, students worked in groups of two or three to generate practice problems and data for statistical tests. Next, students solved the problems they created. Groups then exchanged word problems and examined each other's work for mistakes. At the end of class, students put their problems in a box. Every other week, students randomly selected problems out of the box and tried to solve them. Because students had to design the problems, they had to think of the types of data that were acceptable for each statistical test. Students reported that the technique was effective in helping them learn statistical concepts.

- Kolar, D. W., & McBride, C. A. (2003). Creating problems to solve problems: An interactive technique for statistics courses. *Teaching of Psychology, 30,* 67-68.

Jigsaw Classroom

Describes a way of combining in-class work on statistical problem sets with a jigsaw classroom. In a jigsaw classroom, the instructor breaks down complex problems into smaller parts, with each student being responsible for a portion of the material. In this way, students have to cooperate and rely on each other for information that will help them learn the material. The authors provided two examples of statistical problems that teachers could use—an ANOVA problem and a chi-square problem. Student evaluations of the activity were positive.

- Perkins, D. V. & Saris, R. N. (2001). A "jigsaw" classroom technique for undergraduate statistics courses. *Teaching of Psychology, 28*, 111-113, doi: 10.1207/S15328023TOP2802_09.

Developing Statistics Portfolios

Describes a portfolio activity for an introductory statistics and methods course designed to integrate statistics concepts into the psychology curriculum. The stated goals of the activity were to improve learning by requiring students to compile information into a concise resource and provide students with a personally relevant resource for future research. The instructor provided guidelines for the portfolios, including a suggested list of topics (with page limits); instructions to explain material in students' own words; and encouragement to provide many examples throughout the portfolio. The instructor and an independent rater evaluated the accessibility, anticipated value, and uniqueness of the portfolio to compile a quality rating. There was a positive correlation between portfolio quality and course grades, while controlling for GPA and math anxiety. Furthermore, advisor ratings showed that students who completed the portfolio assignment required less assistance on their senior theses than students who did not.

- Scuitto, M. J. (2002). The methods and statistics portfolio: A resource for the introductory course and beyond. *Teaching of Psychology, 29*, 213-215. doi: 10.1207/S15328023TOP2903_07.

Teaching Calculations

Examined whether requiring students to complete statistical calculations resulted in improved comprehension. Seabrook examined the relation between calculation competence and statistical thinking, while controlling for scores on a pretest and grades in the course. The control variables accounted for 26% of the variance in statistical thinking scores, whereas computational competence accounted for an additional 2%, which was significant.

- Seabrook, R. (2006). Is the teaching of statistical calculations helpful to students' statistical thinking? *Psychology of Learning and Teaching, 5,* 153-161.

Online Tutorial Generator

Describes an online tutorial generator for statistics concepts called Statistical Understanding Made Simple (SUMS) (http://www.gla.ac.uk/sums), which allows instructors to upload data and then construct tutorials based on those data. Topics covered in the tutorials include measures of central tendency, understanding standard deviation, the normal curve, *t* tests, correlations, and interpreting *p* values. Each tutorial includes three steps: (a) a description and explanation of the statistical concept; (b) exploration of the concept using an interactive component; and (c) application of the information to an example, using the instructor's data. In this study, use of the SUMS system was positively correlated to statistics comprehension and self-efficacy.

- Swingler, M.V., Bishop, P., & Swingler, K.M. (2009). SUMS: A flexible approach to the teaching and learning of statistics. *Psychology Learning and Teaching, 8,* 39-45.

Monte Carlo Software

Describes a computer program called MC4G that teachers can use to explain statistical concepts. The software comes with an instructor's book that helps the instructor perform Monte Carlo simulations to explain robustness, power, and sample size analysis. The authors used MC4G to demonstrate robustness after presenting a lecture on the assumption of homoscedasticity when studying ANOVAs. Students reported that the computer simulation helped their understanding of the topic. Students in the computer simulation group also scored higher on an exam than a control group that did not view the demonstration.

- Raffle, H., & Brooks, G. P. (2005). Using Monte Carlo software to teach abstract statistical concepts: A case study. *Teaching of Psychology, 32,* 193-196.

Content-Related Activities

Main Effects and Interactions

Describes a baking analogy to teach main effects and interactions. The instructor described each independent variable as an ingredient in the recipe with the dependent variable being taste perception. The instructor introduced each ingredient for cookie dough separately and asked students if their taste perception of that ingredient was positive. The instructors also presented the ingredients in different amounts to show that in recipes and in statistics, certain levels of each independent variable are necessary to produce an effect. Finally, the ingredients produced an interaction: the completed cookie. Students in the baking analogy scored higher on a three question posttest than students in a control group.

- Christopher, A.N. & Marek, P. (2009). A palatable introduction to and demonstration of statistical main effects and interactions. *Teaching of Psychology, 36,* 130-133.

Chance

Describes an interactive way of teaching the concepts of chance and random occurrences. Students formed dyads and guessed the flavor of a Life Saver while closing their eyes or holding their noses shut. Students then reported whether they identified the correct flavor. Afterwards, the instructor informed students that approximately 20% of them would correctly identify the flavor (i.e., chance). The instructor then gave a follow-up lecture to emphasize the concept of chance. The authors found that students performed well on exam questions related to random events.

- Christopher, A. N. & Marek, P. (2009). A sweet tasting demonstration of random occurrence. *Teaching of Psychology, 29*, 122-125, doi: 10.1207/S15328023TOP2902_09

Random Assignment

Describes a playing card demonstration for teaching random assignment. The instructor randomly distributed cards to two groups of students. Next students in the groups compared their cards for different characteristics (e.g., numbers, suits of the cards) and recorded the number of times each characteristic appeared in the group. Typically, characteristics in the two groups were roughly the same, which showed that each characteristic is probabilistic. Students in the card condition scored higher on the posttest assessment.

- Enders, C. K., Laurenceau, J. & Stuetzle, R. (2006). Teaching random assignment: A classroom demonstration using a deck of playing cards. *Teaching of Psychology, 33*, 239-242.

Multiple Regression

Describes an activity to illustrate the concept of multiple regression. The goals of the activity were to show students a personally relevant example of multiple regression and to reduce students' anxiety about learning statistics. Students collected movie reviews of films they had recently seen and provided their own ratings of those movies. Using this information, the instructor taught about predictors (movie reviews), criteria (students' enjoyment of the movie), predicted enjoyment based on the regression equation, and residuals (difference between the predicted rating and the actual rating). The authors also discussed how to incorporate other multiple regression concepts into the activity. Students reported enjoying the activity and that it helped with their understanding of multiple regression.

- Garcia, C. & Garcia, M. T. (2004). Cinema and multiple regression. *Teaching of Psychology, 31*, 56-58.

Central Limit Theorem

Describes an activity to teach the Central Limit Theorem (CLT). The instructor assigned higher numbers to face cards in a deck of playing cards and designated an ace as equaling one. The instructor plotted how many of each card exists in two decks (which produces a flat distribution). Next, the instructor gave each student a sample of three cards from the decks and asked them to calculate their sample mean. The instructor plotted each of the means, which resulted in a normal distribution, and then explained the CLT. Students who viewed this demonstration received higher grades on an open-ended assessment than students in a control condition.

- Matz, D. C. & Hause, E. L. (2008). "Dealing" with the central limit theorem. *Teaching of Psychology, 35,* 198-200.

Applied Statistics Project

Describes using personal ads to create a statistical application project. The instructor asked students to select personal ads from a newspaper as long as the people in the ads provided their names and the minimum and maximum ages for people they were seeking. There were three sets of 25 ads from three different decades. Students received specific instructions and recorded the ages and genders of people in the ads and the time period of the ad. Students then compared the ads using Pearson correlations and ANOVAs and wrote the Methods and Results sections of an APA style paper. The authors found that students' performance on final exam items related to these concepts exceeded 90%.

- Rajecki, D. W. (2002). Personal ad content analysis teaches statistical applications. *Teaching of Psychology, 29,* 119-122.

Standard Error of the Mean

Describes an activity to help students understand standard error of the mean. The instructor used two bags filled with slips of paper with different values (e.g., 0, 3, 6). Each bag represented a population, with one representing a situation where the null hypothesis was true and one representing a situation where the alternative hypothesis was true. In both bags, the same values were represented, but in different frequencies, resulting in different means for the two "populations." Students drew three pieces of paper from the bag with replacement. They calculated the mean of their sample, got into groups, recorded the values from their group members, and calculated the sample mean. The instructor then made a sampling distribution from the entire class to demonstrate the Central Limit Theorem. Exam performance was higher for those students who completed the exercise.

- Ryan, R. S. (2006). A hands-on exercise improves understanding of the standard error of the mean. *Teaching of Psychology, 33,* 180-183.

Sampling Distributions and the Central Limit Theorem

In this statistics activity, undergraduate students used the landscape at their university to learn about sampling distributions and the Central Limit Theorem. Students in two statistics courses counted the number of roses on rose bushes around campus. The students sampled either 30 bushes or 60 bushes and then computed means and standard deviations for their samples. Student responses indicated that they enjoyed the activity. Furthermore, understanding improved following the activity. The authors suggested using the natural environment to encourage activity and engagement in the statistics course.

- Schoenfelder, E., Olson, R., Bell, M., & Tom, K. (2007). Stop and smell the roses: An activity for teaching the central limit theorem. *Psychology of Learning and Teaching, 6,* 80-84.

Factors Affecting the F-ratio

Describes a class activity for illustrating the impact of effect size, individual differences, and measurement error on power in an ANOVA test. The instructor assembled two boxes, one labeled "between" and one labeled "within," and selected

items of different weights to represent individual differences (e.g., an action figure), measurement error (e.g., a stopwatch), and treatment effect (e.g., batteries of different sizes). The instructor then manipulated the weights of the different boxes using the items and asked students to determine if the boxes were of equal weight. The instructor also manipulated the conditions under which students made their estimations. For example, in one situation, each box contained only measurement error and individual differences. In other cases, the instructor added different-sized batteries to the "between" box. Students were more certain of a difference with the larger treatment effect (i.e., battery) sizes. Students reported that the activity was useful in understanding the *F*-ratio.

- Scuitto, M. J. (2000). Demonstration of factors affecting the *F*-ratio. *Teaching of Psychology, 27,* 52-53.

Factor Analysis

Describes a way in which undergraduate teachers of statistics (or other courses) can introduce the complex concept of factor analysis. The authors suggested introducing the concept with a personality test example or when introducing the concepts of instrument development. To illustrate the concept, instructors developed a set of hypothetical instrument items relating to a specific concept (e.g., anger, health, optimism/pessimism). In addition, the instructors wrote several items that would relate to more than one category and several items that would be negatively correlated with other items. During the activity, each student selected an item and, then, by discussing their items with other classmates, formed a group of items that would likely relate to each other. With their group members, the students then constructed a name for their group of items. The ensuing lecture discussed how students made their decisions and how a statistical factor analysis works. Students enjoyed the activity and performance on related test items was slightly improved, compared to students in a course with no factor analysis activity.

- Segrist, D.J. & Pawlow, L. A. (2007). The mixer: Introducing the concept of factor analysis. *Teaching of Psychology, 34,* 121-123.

General Activities

Reducing Student Anxiety

Describes a technique to reduce student anxiety toward statistics on the first day of class. The instructor had students complete a questionnaire that contained questions about their level of anxiety about the course. Next, students drew numbers from a bag, which the instructor then wrote on the board. The students then answered questions about their numbers, such as overall mean of the distribution and the distance a particular number was from the mean. The instructor then demonstrated that with more and more numbers, students could be more confident about their guesses. A posttest revealed less student anxiety towards statistics.

- Bartsch, R. A. (2006). Improving attitudes toward statistics in the first class. *Teaching of Psychology, 33,* 197-198.

Active Involvement

Describes a method of teaching that uses students' bodies and the space in the classroom to talk about statistical concepts. It involved students standing at the front of the class on an imaginary number line corresponding to a rating scale (e.g., strongly disagree to strongly agree). Students then answered questions regarding how they felt about different topics. By physically moving to the point that corresponded to their own opinions, students could clearly see the distribution of the responses in class. Other examples involved a human scatterplot to describe correlation and regression. This exercise interested students, who reported that it nicely complimented the textbook. The author subjectively noted that this exercise helped decrease the negative association students had with statistics.

- Connor, J. M. (2003). Making statistics come alive: Using space and student's bodies to illustrate statistical concepts. *Teaching of Psychology,30,* 141-143.

Teaching Core Terms in Statistics

Evaluated the importance of teaching different concepts discussed in undergraduate statistics texts. The author compiled a list of 374 statistical terms from introductory statistics texts and then surveyed a sample of statistics instructors across the United States regarding the importance of teaching the different terms. The author randomly divided the list of 374 items into three different, orthogonal lists before distributing them to the statistics instructors. Approximately 63 instructors rated each item's importance (1 = *slightly important*, 2 = *moderately important*, 3 = *extremely important*). The author listed the top 100 concepts to teach in a statistics course, the top five of which were normal curve, statistically significance, bell-shaped curve, significance level, and hypothesis testing. This article would be useful for teachers who are deciding what concepts to cover in their courses.

- Landrum, R. E. (2005). Core terms in undergraduate statistics. *Teaching of Psychology, 32,* 249-251.

Statistical Reasoning

Describes a handout used to teach statistical reasoning to students. Three sections of a psychological statistics course received a handout divided into six parts that included information on statistical reasoning for everyday problems. Each part of the handout included text and practical reasoning exercises that students completed outside of class. The students completed a statistical reasoning assessment before and after the course. Students who received the handout improved more on statistical reasoning than students who did not use the handout. The authors provided examples of the statistical reasoning problems in the article.

- Lawson, T. J., Schwiers, M., Doellman, M., Grady, G., & Kelnhofer, R. (2003). Enhancing students' ability to use statistical reasoning with everyday problems. *Teaching of Psychology, 30,* 107-110.

Music as a Mnemonic

Describes using music as a statistical mnemonic. Students in one section of a psychological measurement course learned and sang three statistical jingles while another section read definitions of terms out loud in class. Both sections took a four-item short answer test related to the definitions and jingles. Two faculty members scored the tests independently of one another. Learning the jingles significantly improved the students' test performance.

- VanVoorhis, C. R. W. (2002). Stat jingles: To sing or not to sing. *Teaching of Psychology, 29,* 249-250.

Simplifying Statistical Concepts

Describes a handout used to help simplify statistical concepts. The authors noted that when instructors expect students to determine which statistical test to use on their own, students often get confused. This humorous handout puts students in the role of a detective on Statistics Street. It is a reference to which students can refer throughout their studies. The authors noted that it might be especially helpful when students have an end-of-course project they must complete on their own. Students reported that the handout was useful.

- Zeedyk, M. S. (2006). Detective work on Statistics Street: Teaching statistics through humorous analogy. *Psychology Learning and Teaching, 5,* 97-109.

References

Adams, N. A. & Holcomb, W. R. (1986). Analysis of the relationship between anxiety about mathematics and performance. *Psychological Reports, 59*, 943-948.

Baloglu, M. (2003). Individual differences in statistics anxiety among college students. *Personality and Individual Differences, 34*, 855-865. doi: http://dx.doi.org/10.1016/S0191-8869(02)00076-4

Kranzler, J. H. (2007). *Statistics for the terrified* (4th Ed.). Upper Saddle River, NJ: Pearson-Prentice Hall.

McClelland, G. (1999). *Seeing statistics*. Retrieved from http://www.seeingstatistics.com.

Rowntree, D. (2004). *Statistics without tears: A primer for non-mathematicians*. Boston, MA: Pearson.

Zeidner, M. (1991). Statistics and mathematics anxiety in social science students: Some interesting parallels. *Teaching of Psychology, 61*, 319-328.