AN APPLICATION OF THE ACTION RESEARCH MODEL FOR ASSESSMENT: PRELIMINARY REPORT

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Introduction

The action research model provides a useful method for examining learning that occurs in the classroom. In this preliminary report, the results from applying this teaching experiment cycle indicate that a discovery-based lesson which includes a writing assignment is an effective tool for students in a post-calculus probability and statistics courses to learn the central limit theorem.

Project Background

Research by del Mas, Garfield, and Chance has shown the action research model is an appropriate method of assessing student learning of the central limit theorem in algebra-based introductory statistics courses. [1] In fact, much of the attention of the reform movement in statistics education has been focused on teaching methods, course content, and using technology in the algebra-based introductory statistics course. [2, 9, 13, 15, 16] In such classes, teachers have been emphasizing statistical thinking, active and collaborative learning, conceptual understanding, the use of data and technology, and communication skills in order to reduce the "wide gap" that David Moore says "separates statistics teaching from statistical practice." [2, 3] In comparison with the efforts in the algebra-based introductory statistics course, little has been done in the post-calculus introductory probability and statistics course. [11] This is in part because many post-calculus introductory probability and statistics courses are heavily frontloaded with probability theory, leaving little time for exploring statistical concepts. In a typical two-semester post-calculus introductory probability and statistics sequence statistical concepts such as statistical significance are often not introduced until the second semester. [11, 4, 7, 8] With the support of National Science Foundation Division of Undergraduate Education Adaptation and Implementation grants*, Lunsford, Rowell and Goodson-Espy are using activity-based discovery learning materials in the post-calculus probability and statistics course at their universities and are applying the action research model as a means of assessment.

The goal of action research, which is also called classroom research, is to gain insight into issues and their underlying sources which effect classroom learning. It is important to understand that action research does not attempt to find a definitive solution to the issue. [1, 5, 6, 10] A model of action research appropriate for statistics education has been developed by del Mas, Garfield, and Chance. Their model is defined by the following four phases which form the bases for a teaching experimentation cycle:

- What is the problem? I.e., what is not working in the classroom?
- What technique(s) can be used to address the learning problem?
- What type of evidence can be gathered to show whether the implementation is effective?
- What should be done next, based on what was learned? [1]

These four phases are utilized in the classroom research described in this paper.

Phase 1: Issues to Consider

For the first phase, the researchers begin by defining issues facing them in their post-calculus probability and statistics courses. Four of those issues are defined in this paper. First, at one researcher's university, math majors who take only one course in "Probability and Statistics" are exposed to very little statistics. This issue is even more important because many of the students in that class are future middle school and high school teachers who will be expected to teach data analysis and statistical concepts in secondary school math courses. Second, all three researchers considered student understanding of complicated concepts to be an issue that needed examining. Some concepts they decided to target are the central limit theorem, confidence intervals, combinatorics problems, and Baye's Theorem. Third, the researchers want to increase *reasoning* and *thinking* instead of memorization. Fourth, they would like to provide better career preparation for the students whether they are math majors, computer science majors, other science majors, or future math or science teachers.

Phase 2: Techniques to Address the Issues

In order to address the learning issues defined in phase one, the researchers used several techniques. The researcher who was concerned about the limited amount of statistical content in the more traditional first course in mathematical statistics worked with her department to change the course description to include probability and statistics in the first course of their sequence. They also lowered the corresponding course number to indicate that the revised course is not as theoretical as it previously had been and that the revised course has a more applied nature.

For the second issue of helping students better understand complicated concepts and increase "thinking" instead of memorization, the researchers integrated new curricular materials into their courses. For this project, they selected two primary sources for the materials: "A Data-Oriented, Active Learning, Post-Calculus Introduction to Statistical Concepts, Methods, and Theory (SCMT)" by Rossman, Chance and Ballman (NSF DUE-9950476), and "Virtual Laboratories in Probability and Statistics (VLPS)" by Siegrist (NSF DUE-9652870). [12,14] These materials were selected because they encourage learning through active student exploration using simulations, both tactile and technology-based, as a means for visualizing concepts. Furthermore, with these materials a variety of problem-solving skills are developed which utilize the mathematical background of these post-calculus students. [11] The researchers consider it an added bonus that these materials make it is quite easy to provide better preparation for careers by seamlessly integrating technology, group work, and writing into the curriculum. This is especially important for the students who will work in industry and for those who will be future secondary mathematics teachers. Using these materials, the preservice teachers are being taught by the data-oriented, activity-based methods that they are expected to use when they teach mathematics and statistics in the middle schools and high schools. [11]

Phase 3: Determining What Evidence to Collect

The next phase in the action research model is to determine the type of evidence that can be gathered to show whether the implementation is effective. In this project, evidence is collected in a variety of ways. A survey is used to determine students' self-perception of their learning of particular probability and statistics concepts. This data is collected at the beginning and end of the semester in order to observe changes in students' perception of their learning. This survey also includes information about student attitudes toward the methods used for teaching. Several methods are used to measure the teacher's perception of student learning including in-class student feedback during the activity (continuous monitoring), follow-up in-class quizzes, student reports, and exam questions.

An Example: The Evidence Collected

The central limit theorem is an important concept for students to gain insight and understanding about sampling distributions. Rossman, Chance, and Ballman [12] developed a lesson which utilizes technology-based simulation (using Minitab) as the means of students discovering the result of the central limit theorem. This computer laboratory discovery-based lesson, "Sampling Distributions of Sample Means" was used by Rowell in a post-calculus introductory applied statistics course during the Spring 2003. The lesson can be found at http://www.mtsu.edu/~rowell/nfsai/clt01.htm. During a class period held in a computer lab, the students completed three of the four examples that are a part of this activity. For homework, students wrote reports of their findings for each example and their overall conclusions. The students also answered a similar question on an in-class exam by going to the computer lab for this portion of the exam. As a comparison, during the Fall 2002 semester when Rowell taught the same course, she lectured for this concept and the students completed only one example from the same activity. However, in the lecture lesson, the example was completed by means of an in-class presentation conducted by Rowell using a computer-projected image onto a ten-foot screen at the front of the classroom. In the Spring 2003, the students worked through the computer simulation either independently or in pairs in the computer lab.

When comparing these two classes, 80% (n=25) of the students who conducted the activity for themselves in the computer lab, working several examples, and writing their findings in a report perceived that the activity "aided learning" while only 23% of the students who listened to the teacher's lecture remembered the activity as one that aided their learning. Another measure of the students' self-perception of their learning was measured by their response on a survey question where they ranked their "understanding of the Central Limit Theorem" on a scale of 1 to 5 with 1 representing low knowledge level and 5 being high knowledge level. The average understanding for the activity-based class was 4.6 (s= .6, n=27), and for the lecture-based class the average understanding score was 3.8 (s=. 9, n=25).

The teacher's perception of student learning included in-class monitoring for the computer lab-based activity. Rowell found that overall the students had minimal difficulty with the assignment. In the Spring 2003 activity-based class, the students wrote a report in which they explained the three examples they had completed, the method they used, and their conclusions. These reports were graded for the big picture concepts and for correctness of conceptual details. On the reports there were only three "wrong" responses (n=27). These incorrect responses were 1) a claim of "I did not know how to do that" on the last question, 2) an incorrect response that "the mean gets smaller", and 3) one incomplete conclusion. The Spring 2003 students used the computer for an in-class exam question for which they used Minitab to simulate a distribution they had not previously simulated. They also examined the distribution of the sample mean for samples of various sizes as they had done on the in-class lab activity. The average score on that question was a 2.6 out of 3 possible points (s=0.7, n=26). The biggest challenge for the students on this exam question was generating the original distribution from which they would draw the samples. They had only minimal experience with this type of simulation using Minitab, and if they missed the original distribution one point was deducted from the three possible points. There was not a comparable question for the students taking this course in the Fall of 2002.

Phase 4: What Should Be Done Next?

The fourth phase in the action research model is the means by which the cycle of using assessment to improve learning begins. In this phase, the researchers ask what should be done next based on what was learned. Clearly, one goal is to improve the methods used in the evaluation stage in order to distinguish whether the simulation, the writing assignment or both are the important piece in student learning. To facilitate this, both Rowell and Lunsford will coordinate their use of this activity, and they will also utilize the central limit theorem pretest and post-test instruments designed by delMas, Garfield, and Chance. [1] Rowell will also improve the writing assignment for this lesson as well as incorporate more report writing in her class. Lunsford has already been including writing as a means of reinforcing student learning. The researchers will continue to use and evaluate these activity-based, discovery learning materials.

Conclusions

The DelMas, Garfield, Chance classroom research model [1] for creating a cycle to improve learning in statistics education is not only applicable to the introductory statistics courses for non-majors but is also valuable in the post-calculus probability and statistics courses. Activity-based, data-oriented, discovery-learning lessons at the post-calculus level are showing promise for improving student learning just as they have done with the algebra-based introductory statistics course. The Rossman, Chance, and Ballman lesson "Sampling Distributions of Sample Means" when combined with a writing assignment to reinforce learning has convinced not only the teacher but also the students that they are learning the concept. These preliminary results are encouraging. However, by incorporating phase four's decisions about what to do next, the teacher experimentation cycle of classroom research can continue and will provide additional information and incentive to make from which to make evidence-based improvements in student learning of post-calculus probability and statistics.

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References

[1] delMas, R., Garfield, J., and Chance B. (1999), A Model of Classroom Research in Action: Developing Simulation Activities to Improve Students' Statistical Reasoning, *Journal of Statistics Education* v7, n3, hosted at http://www.amstat.org/publications/jse/secure/v7n3/delmas.cfm.

[2] Gordon, F, and Gorden, S., Editors (1992), *Statistics for the Twenty-First Century, MAA Notes, Number 26*. The Mathematical Association of America.

[3] Hoaglin, D. and Moore, D. S., Editors (1992), *Perspectives on Contemporary Statistics, MAA Notes Number 21*. The Mathematical Association of America.

[4] Hogg, R. and Tanis, E., (2001), *Probability and Statistical Inference, 6th Ed.*, Prentice Hall Inc.

[5] Hollins, E. R. (1999), "Becoming a Reflective Practitioner," in *Pathways to Success inSchool: Culturally Responsive Teaching*, eds. E. R. Hollins and E. I. Oliver, Mahwah, NJ: Lawrence Erlbaum Associates.

[6] Hopkins, D. (1993), *A Teacher's Guide to Classroom Research*, Buckingham: Open University Press.

[7] Larsen, R. J. and Marx, M. L. (2001), *An Introduction to Mathematical Statistics and Its Applications, 3rd Ed.*, Prentice Hall, Inc.

[8] Miller, I. and Miller, M. (1999), *John Freund's Mathematical Statistics, 6th Ed*. Prentice-Hall.

[9] Moore, T. L., Editor, (2000) Resources for Undergraduate Instructors Teaching Statistics, MAA Notes Number 52. The Mathematical Association of America and The American Statistical Association.

[10] Noffke, S., and Stevenson, R. (eds.) (1995), *Educational Action Research*, NY: Teachers College Press.

[11] Rossman, A. and Chance, B. (2002), "A Data-Oriented, Active Learning, Post-Calculus Introductory to Statistical Concepts, Methods, and Theory," in Proceedings of the Sixth International Conference on Teaching Statistics, July 7-12, 2002, Cape Town, South Africa, hosted at www.rossmanchance.com/scat/ICOTSpaper02.htm.

[12] Rossman, A., Chance, B., and Ballman, K. (1999), *A Data-Oriented, Active Learning, Post-Calculus Introduction to Statistical Concepts, Methods, and Theory (SCMT)*, funded by the Course, Curriculum, and Laboratory Improvement program of the National Science Foundation, award #DUE-9950476, June 1, 1999, hosted at http://www.rossmanchance.com/scmt.html

[13] Rossman, A. and Short, T. (1996), STATS: Statistical Thinking with Active Teaching Strategies, funded by the UFE program of the National Science Foundation award #DUE 9554621, 1996-1999.

[14] Siegrist, K. (1997), *Virtual Laboratories in (Probability and) Statistics*, funded by the Course, Curriculum, and Laboratory Improvement program of the National Science Foundation, award #DUE-9652870, Jan. 1997 – Dec. 1999, hosted at http://www.math.uah.edu/stat/index.html

[15] Snell, L., Doyle, P., Garfield, J., Moore, T., Peterson, B., and Shah, N., (1999), *Chance Project Website, including Chance News and Chance Course*, funded by NECUSE and NSF DUE, hosted at http://www.dartmouth.edu/~chance/

[16] Velleman, P. (1996), *Interactive Video Resources for Learning Statistics*, DUE Course and Curriculum Program of the National Science Foundation, award #DUE 9555233.