Towards a Community of Learners: A Case Study Approach to Statistics

The Department of Mathematics at Elon University is committed to quality instruction and to the incorporation of new and innovative methods of engaging students in the mathematical sciences. This project seeks to investigate the usefulness of the case study approach to teaching in MTH 212: Statistics in Application. As in most core courses, MTH 212 instructors are faced with finding new ways to engage multiple majors at once in an attempt to reach a positive outcome for student-centered learning. While case studies have been used extensively as a teaching tool in fields such as medicine and related professional education fields for many years, this approach is not as widely used to teach undergraduate courses in the mathematical sciences. Instead of "another mathematics course" where students perform rote calculations or are lectured to, they are exposed to a series of real-world case studies that require them to work in groups and apply course content to solve problems. In this setting, they not only develop critical thinking skills, but also acquire useful skills in collaboration, communication, and real-world problem-solving. This classroom approach will help reinforce Elon's commitment to "… put[ting] knowledge into practice, thus preparing students to be global citizens and informed leaders motivated by concern for the common good".

Statistical instruction is an integral part of this mission because it helps students recognize that personal decisions should be based on evidence (data) and that acting on assumptions not based on data may be dangerous. This project and its success will serve as a model within the department and university for the development of other innovative inquiry-based applications in the classroom.

Project Description

Statistics as a discipline demands to be taught in an applied context. The best way to accomplish this is through hands-on activities that help students more critically consider the relationship between

theory and application. The need for new approaches to teaching mathematics has become more evident as both the student and the Statistics landscape has changed. Elon students are arriving more prepared than ever and are demanding to be challenged with innovative teaching. In recent years, new movements in Statistics education have been motivated by the American Statistical Association (ASA) funded report entitled *The Guidelines for Assessment and Instruction in Statistics Education* (GAISE) [1]. The GAISE College report deals specifically with teaching college-level introductory statistics courses and gave six recommendations:

1. Emphasize statistical literacy and develop statistical thinking.
2. Use real data.
3. Stress conceptual understanding rather than mere knowledge of procedures.
4. Foster active learning in the classroom.
5. Use technology for developing concepts and analyzing data.
6. Use assessments to improve and evaluate student learning.

If supported, this project will help to simultaneously incorporate all 6 of these recommendations into MTH 212: Statistics in Application. The report states that:

> It is important to use real data in teaching statistics, for reasons of authenticity, for considering issues related to how and why the data were produced or collected, and to relate the analysis to the problem in context….An important aspect of dealing with real data is helping students learn to formulate good questions and use data to answer them appropriately based on how the data were produced.

Not only will the students be analyzing real data, but the activity-based nature of the course will help ensure that they are engaged in the learning process as they consider collection and production issues. In this way conceptual understanding may be stressed rather than mere knowledge of procedures and/or rote calculations. Students will thus be afforded the opportunity to discover, construct and analyze statistical ideas. Case studies based on real data will also allow the students to practice thinking and communicating statistically because I believe that conceptual understanding leads to better interpretation of results, which in turn leads to better statistical thinking. Students will thus have the opportunity to form their own hypotheses first and explore the question as they work

in groups to solve the case. This will also aid the instructor in identifying and correcting misconceptions since students will be expected to write written reports discussing the data collection techniques, identifying possible issues and analyzing the collected data.

While some textbooks are moving towards "realistic" data, the subjects of these data sets tend to be of less interest to the students. Most statistics texts often also give problems without context so students are unable to extend the techniques from the book to the world around them. It is my experience that students learn better when they collect data on themselves and are afforded the opportunity to learn from their peers. This use of technology not only helps students collect and analyze data but may also aid in visualizing and understanding abstract ideas. As Nuames & Nuames [2] notes,

> the case method is an active pedagogical process as opposed to the passive process that ensues from lecture…For most students and purposes, learning by doing provide far better and more lasting results than learning through lectures…students are thus learning how to think, rather than being told how to approach the subject (p. 5).

To be clear, while case studies are traditionally used either at the beginning or end of a traditional lecture as an application or example, the method proposed here will actually see the students being exposed to the content for the first time as they go through the case study. By doing so it is hoped that the students see the relevance of the content in helping resolve whatever problems they are working on.

This approach is attractive to me as a teaching tool since it supports my teaching philosophy which revolves around situated learning. The two basic principles of situated learning are that for learning to occur 1) both social interaction and collaboration are required, and 2) problems must be presented in the contexts in which they are applied [3]. Through the process of "legitimate peripheral participation", the authors assert that as the learner moves from a novice role (on the periphery) to an expert role at the center of the community, he or she becomes more actively engaged and invested in the culture. It is believed that knowledge is acquired through this

community participation [4]. Having students work in groups to solve real world cases is thus a good manifestation of this philosophy.

Project Objectives &Outcomes

My overall goal for this project is to arrive at a useful understanding of the developmental stages involved in solving authentic problems involving statistics. The purpose of the research is to investigate critical thinking/problem solving development skills among statistics students. Specifically I plan to investigate the effectiveness of the case-study approach as a teaching and learning tool. The following preliminary questions are of primary interest:

- Does teaching using the case study method give evidence on student learning?
- Does this method lead to more authentic problem solving?
- What do students *believe* are necessary skills for problem solving?
- What skills do students use when faced with a problem?
- Does the case-study method help with transfer between classes?

As currently envisioned, the case study approach will be tested in MTH 212 courses during the 2009-11 academic years. The effectiveness of the method in helping students understand statistical concepts will be evaluated based on two primary data collection activities:

- *1: Student and Instructor Reflective Journals*

The students and instructor will be required to keep journals reflecting on each case that provide feedback not only on the operation of the overall course but also on group dynamics, unresolved questions from cases that may lead to future lessons and personal reactions to findings/cases. This is a very important component because as Hutchings [5] notes, it is "difficult […] for students to

reflect on and assess their own experiences as learners, to get past the idea of learning as something that happens to them (or not), to see their education as something they can create and control".

- *2: Group Classroom Videotaping & Individual Think-Alouds*

The ideal plan for the main research questions will involve videotaping classes while students are working to solve a case, as well as calling in individuals or groups for think-alouds to obtain direct information on problem solving techniques. For the general in-class taping, students will just go through their normal classroom routines while being videotaped. With some individual students I will use think-alouds which is a technique that is used to make some of the thinking that is invisible in normal circumstances visible. Specifically, in a think-aloud, a person is video or audio taped and asked to read or solve a problem or recount information, and to do so while saying out loud everything that is going on in his or her mind while he/she does so.

In addition to the question of improved student learning, the effect on student attitudes is also of interest. The *Survey of Attitudes towards Statistics* (SATS) [6, 7, 8] will be used to measure not only how students feel about Statistics, but how important they think Statistics is in their field of study. It is thought that this is an important component of a student's motivation to learn Statistics. The SATS contains 28 seven-point items designed to assess four components of students' attitudes toward statistics. These components include:

1. Affect: Students' positive and negative feelings about statistics.
2. Cognitive Competence: Attitudes about the student's intellectual knowledge and skills when applied to statistics.
3. Value: Attitudes about the usefulness, relevance, and worth of statistics in personal and professional life.
4. Difficulty: Attitudes about the difficulty of statistics as a learning domain.

Seventeen additional items ask for demographic, academic background, self-confidence, and expected course grade information. Pre- and post-course versions are available and students usually complete the SATS in about 10 minutes.

Use of real data is widely accepted in the Statistics education community as beneficial to student learning and attitudes, but no concrete data are available. The researcher is unaware of any other projects to assess student learning outcomes using the case study approach. Due to the increased search for inquiry-based methods of teaching statistics, this will thus also be of interest to the Statistics community.

Students will be required to write reports at the end of each case. The report-writing aspect also has implications in fields other than Statistics since statistical tools are used in many disciplines. Students from almost every discipline have a need to collect and/or analyze data collected from their research or class projects. It is anticipated that students will have a better understanding of how statistical analyses can be applied to real data which in turn will help students put their statistical knowledge to use in future classes. Another possible outcome of this project will be expanded use of case studies in other Statistics courses such as MTH 112: General Statistics.

Project Impact on Elon

On average, I teach between 3 and 5 sections of MTH 212 each year. This project thus fits in well with my teaching responsibilities and has long-term significance on teaching and learning since it incorporates an assessment strategy that can be used to measure how well stated course goals are being met, and whether the course is in-line with the recommendations of the American Statistical Association and Elon's commitment to engaged learning. Annually, over 200 students take this course from dozens of majors so this project will reach many students here at Elon.

Products and Dissemination

I anticipate being able to publish and present these findings to the statistics community (there are tons of journal options). My goal is to publish at least 2 papers of findings, and to present at the United States Conference on Teaching Statistics (USCOTS) in May 2011 and the Joint Statistical Meetings (JSM) in August 2011. I also anticipate submitting successful case studies to the case study repository at The University of Buffalo, a leader in case study use in science. These should also be of interest to AP statistics teachers and others who may be interested in authentic teaching practices.

Timeline & Budget

Due to IRB rules, work involving student data cannot be analyzed while the students are enrolled in the class. As such, there will be a delay in the actual transcription and initial analysis of data.

Fall 2009 O Train student assistants to take active notes O First group video and individual think-alouds. O Work on writing new case studies	**Winter 2010** O Transcription of videotapes from Fall 2009 & Coding	**Spring 2010** O Train student assistants O Second group of videotaping and think-alouds O Analyze data from Fall 2009	**Summer 2010** O Transcription of videotapes from Spring 2010 & Coding O Analysis of Fall and Spring data O Preliminary findings (I should have a large enough sample by then)
Fall 2010 O Train student assistants to take active notes O Third group of videotaping and think-alouds O Begin work on journal articles based on preliminary findings	**Winter 2011** O Transcription of videotapes from Fall 2010 & Coding	**Spring 2011** O Analyze and disseminate—at least 2 journal articles and 2 presentations—One at United States Conference on Teaching Statistics (USCOTS) in May 2011 & JSM in August 2011	

Funds will be used to pay for student assistants who will help with video transcription and with in class videotaping, and travel to conferences/workshops on case studies and statistics.

2009-2010 Funds: Pay student stipends; Travel to workshop on writing case studies

2010-2011 Funds: Pay student stipends; Travel to conference for presentation

In closing, the findings of this research will be of interest not only to the statistics education community, but to all communities of learners who may consider such methods as a means of strengthening student content knowledge and their understanding of learning. The CATL scholar program will provide me with the opportunity to share/obtain perspectives on the advantages and issues with using case studies and an inquiry-based learning approach to teaching. I hope to explore methods of incorporating inquiry-based learning into core courses, obtain ideas for the development of case studies and find out ways to engage multiple majors at once in an attempt to reach a positive outcome for student-centered learning.

REFERENCES

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