THE RE-DESIGN OF A STATISTICS COURSE

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Abstract

This project describes a re-thinking of a traditional Probability and Statistics course using the components of backward course design, supplemental instruction, project and activity based learning, and the use of new technology.

Introduction

Probability and Statistics, Math 2600 at Georgia College, is a sophomore-level course, primarily serving students who are fulfilling a core curriculum or non-mathematics major requirement. Many will encounter statistics formally in discipline-specific contexts. Certainly, all will face statistical language and conclusions in the media and issues related to personal, political or civic life. Therefore, applications, interpretations, and hands-on data analysis are crucial skills for these students. Typically, students spend the majority of their time learning *about* statistics rather than engaging in the statistical method of data analysis.

Innovations or modifications to such a service course are complicated by the common textbook and learning outcomes across all sections, taught by multiple instructors. Access to technology can also be a hindrance. This on-going project at Georgia College addresses such challenges by using backward course design and easily accessible technology to help students achieve the stated learning outcomes. Finally, supplemental instruction - funded by the Georgia College STEM Initiative – provides students with access to peer tutoring and additional help with the technology by advanced undergraduate mathematics majors.

Revising Learning Objectives

Grant Wiggins and Jay McTighe present the process of backward course design in *Understanding by Design*. Their method describes three main stages of course design or re-design:

- Identify desired results
- Determine acceptable evidence
- Plan learning experiences and instruction

In the first stage, the big ideas for enduring understanding are identified and learning objectives are crafted [4]. In this project, the overarching goal of the re-design is to transition students from simply learning about statistics to engaging in statistical data analysis, and we will focus on writing, revising, and refining the course learning objectives that support the overarching goal. The work of Barbara Tewksbury & Heather Macdonald [3] and Linda Nilson [2] provide guiding principles for revisions of the existing common course outcomes from Math 2600. Tewksbury describes four important characteristics of learning outcomes. They should be student-centered, measurable, concrete, and focus on the higher-order skills as described, for example, in Bloom's Taxonomy [1].

As the learning outcomes for Math 2600 Probability and Statistics at Georgia College are common among all sections of the course, official modifications are not made individually by one instructor. However, for planning purposes, the learning objectives can be re-structured for the guidance of one instructor's pedagogical choices. Such is the process undertaken in this project. The stated common learning outcomes for Math 2600 at Georgia College are stated below.

Common Course Outcomes for Math 2600

As an outcome of this course, students will be able to:

- Calculate and interpret basic descriptive statistics;
- Calculate probabilities for simple events from a variety of random experiments;
- Describe and use properties of basic probability distributions;
- Understand and be able to perform statistical inference in the form of confidence intervals and hypothesis tests;
- Review with a more critical eye public information that informs decisions in our world today;
- Use appropriate technology in the evaluation, analysis, and synthesis of information in problem-solving situations.

After reviewing these learning outcomes, we determined that they are indeed student-centered in that they focus on the skills and behaviors of the students rather than the actions taken by the instructor. They are also primarily concrete and measurable. The challenge in this set of outcomes is the combination of higher order and lower order thinking skill in each outcome. In her book, *The Graphic Syllabus and the Outcomes Map*, Linda Nilson defines a hierarchical method of categorizing learning outcomes by defining foundational, mediating, and ultimate outcomes to distinguish between and organize the higher order and lower order thinking skills encompassed in course outcomes. Ultimate outcomes generally require integration of multiple skills and are the most challenging tasks. Each mediating outcome will address one component of an ultimate outcome. And finally, the foundational or basic outcomes address the lower order skills required to meet the mediating outcomes [2]. The common course outcomes for Math 2600 were re-structured accordingly and are listed below.

Re-structured learning objectives used to guide this project:

Ultimate
Upon successful completion of the course, students will be able to:

- Evaluate the validity of statistical inferences, through data analysis, concerning important professional or public issues.

Mediating
Upon successful completion of the course, students will be able to:

- Interpret basic descriptive statistics (such as mean, median, standard deviation, percentile, and quartile) in a variety of contexts.
- Apply basic properties of probability distributions.
- Perform statistical inferences in the form of confidence intervals and hypothesis tests.
- Use appropriate technology in the analysis and synthesis of information in problem-solving situations**.**

Foundational or Basic
Upon successful completion of the course, students will be able to:

- Calculate basic descriptive statistics.
- Describe properties of basic probability distributions.
- Calculate probabilities for sample events from a variety of random experiments.
- Understand statistical inferences.
- Choose appropriate technology in problem solving.

Implementation in Math 2600

The final stage of the backward design process is to plan learning experiences and instruction. The re-design was first implemented in four sections of Math 2600 in Spring 2012 and subsequently in one section in Summer 2012 with plans for continuation in Fall 2012. The two most notable pedagogical changes are i) the role reversal between lectures and in-class activities or group work and ii) the introduction of group projects. Historically, this instructor used an interactive lecture style with occasional group work or activity for Math 2600. Data sets used in problems were required to be relatively small and somewhat artificial because of the reliance on the graphing calculator for analysis. With the implementation of this re-design, however, guided group work activities and discovery are the primary method for delivery of content, concept development, and skill building. Lectures and instructor board work are rare. The students now generate the majority of the data used in the class through surveys and experiments and use the web-based package StatCrunch© to subsequently analyze data. Thus the data sets can be larger and students see exactly how the data was generated.

Students completed one project that incorporated survey design, data collection, descriptive statistics, and correlation and a second project involving data collected from reliable internet sources to conduct a hypothesis test. Due to time constraints, only the first project was presented in class. Again, StatCrunch© was used to analyze data and to generate, share and present reports. Since this application is web-based, groups had the flexibility to work together on or off campus.

Supplemental Instruction

As a result of funding from the Georgia College STEM Initiative, two undergraduate mathematics majors acted as supplemental instructors to support the students in all four sections of Math 2600 involved in the re-design. In addition to facilitating in-class activities and group work, the supplemental instructors held weekly problem solving and computer lab sessions to assist students with homework problems and computer based work. We saw that 54% of the enrolled students participated at some point in outside of class SI sessions during Spring 2012. Although not necessary components of the course re-design, the contributions of supplemental instructors were perceived to be quite beneficial by the students and the course instructor.

Student Assessment of Learning Gains

The Student Assessment of Learning Gains (SALG, http://salgsite.org/) survey is designed to collect students' own assessment of their learning as a result of a course. Questions are aimed not only at content knowledge acquisition but also at concept development and transferrable skills. Students are asked to report on their learning gains with a rating ranging from "1: No Gain" to "5: Great Gain". The SALG was administered to the students of Math 2600 in Summer 2012. Twenty-one of the twenty-four enrolled students completed the survey. Some summary results for selected questions are given in Figure 1.1 below.

Figure 1.1 **Summary Statistics for SALG Survey - Summer 2012**

Question	n	Mean	Std. Dev.
As a result of your work in this class, what gains did you make in the following?			
How studying statistics helps people address real world issues.	21	4.19	0.87
Data collection and exploration.	21	4.05	0.97
Designing and implementing a statistical study.	21	3.76	0.70
Identifying correlation between two quantities.	21	3.81	0.87
Recognizing statistical significance.	21	3.81	1.03
Ability to make statistical interpretations outside of the context of this class.	21	3.67	1.02

How much did each of the following aspects help your learning?			
Attending class	21	4.57	0.75
Participating in class activities	21	4.29	0.96
Computer lab sessions	21	3.90	1.22

Conclusions

This project is on-going, and baselines must be established to make conclusive comparisons. Nonetheless, the preliminary feedback from the SALG survey shows high perceived gains in the targeted areas of the re-design – namely "real-world" applications and data collection and analysis. Also, students indicate that class and computer lab activities contribute to their learning. These results are encouraging and will inform the continuation and possible expansion of this re-design.

Students have also been quite candid on a daily basis about how the methods have affected their learning, and modifications are continually considered. The primary challenges have been in maintaining integrity of the groups over the course of the semester and building student confidence in their own abilities to discover.

References

[1] Bloom, B. S., *Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I, Cognitive Domain,* 1st ed.; Longmans, Green: New York, 1956.

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[3] Tewksbury, B., Macdonald, H., *On the Cutting Edge,* On-line Course Design Tutorial funded by NSF grant DUE-0127310, http://serc.carleton.edu/NAGTWorkshops/coursedesign/tutorial/index.html, 2005.

[4] Wiggin, G., McTighe, J., *Understanding by Design*, Prentice Hall, 2001.