PCCI Final Report

Course Developer(s) Information

Name: Curtis Bennett
Department: Mathematics

Name: Suzanne Larson
Department: Mathematics

Course Title: Quantitative Skills for the Modern World

Bulletin Description:
Quantitative and analytic skills used to understand personal and social issues faced in everyday life. Topics include problem solving, computer spreadsheets, probability and statistics, and the mathematics of finance.

I. Situational Factors
Most BCLA and CFA students, except those majoring in psychology, economics and liberal studies, satisfy their math core requirement by taking Math 102 (Quantitative Skills for the Modern World). This course is designed to provide students with quantitative and analytic skills that are useful in understanding personal and social issues faced in everyday life. Topics include number sense, mathematics of finance, probability, statistics, and computer spreadsheets. All sections of Math 102 use a somewhat standardized syllabus. Also, as part of the course, all students enrolled in Math 102 attend a weekly 75-minute computer lab period in which they learn to use the spreadsheet application Microsoft Excel to analyze real problems. Each section of Math 102 typically enrolls 25 – 30 students. There is a fairly wide range in student mathematical ability and student attitude towards mathematics in a typical section of Math 102. As indicated by pre-course surveys administered over several semesters, many Math 102 students begin the class saying that they do not see mathematics as relevant to real-world problems.

We incorporated open-ended group investigations in Math 102 that require students to apply quantitative and analytical skills in addressing contemporary issues. Students had to interpret the meaning of their results in terms related to the financial, social or other situation from which the problems arose, in addition to using the correct quantitative terms. Requiring short reports and/or oral presentations of their results reinforced written and oral communication skills.

Descriptions of the three group investigations we created follow.

- Descriptive Statistics
For this project, we have carefully created six sets of data on light bulb longevity for six different brands of light bulbs. Each student group received a set of data for one brand of light bulb. They were required to calculate descriptive statistics,
determine which statistics to present and how to present them so that the class would vote to buy their brand of light bulbs. Later, students were given the full data set for all six brands of light bulbs and students discussed again what brand is best. The goal was for students to see how to make and critique arguments that use descriptive statistics.

- **Voting power project**
  Students began this project by playing the role of a campaign manager for a candidate with certain financial and strategic constraints and who is to design an optimal spending strategy for their candidate. From there, students learned about the Banzhaf voting power index for measuring voter power in election situations. At the end of the project, students calculated the Banzhaf voting power index of an individual voter in each of two U.S. states, then considered how this reflected upon the U.S. Electoral College system and used this evidence to write a letter to the editor arguing for or against eliminating the Electoral College.

- **Tax Project**
  The project on taxes required students (i) to calculate marginal and effective rates of taxation, (ii) to identify different types of tax structures (payroll tax, income tax, sales tax) and observe how such structures affect effective and marginal tax rates, (iii) to use the notions of marginal and effective tax rates to critique quantitative arguments about tax policies, and (iv) to use the notions of marginal and effective tax rates to suggest tax policy changes. Finally, the project requires students to write a letter to their congressperson (at least 500 words), suggesting a change in the tax code to make it fairer and to construct a graphic using Excel that will help to make the point of the letter.

II. **Learning Goals**
The general learning goals Math 102 are:
1. Students will be able to use mathematical terminology and apply quantitative methods appropriately.
2. Students will be able to use quantitative reasoning to draw conclusions and make arguments.
3. Students will be able to recognize quantitative issues in a variety of settings.

Our aim in incorporating the three group projects into the course was that they would help to achieve all three of these goals. For each of the group projects, we stated specific learning goals as follows.

**Learning Goals for Descriptive Statistics Project**

**Factual/Procedural/Schematic**
1. Students will be able to calculate measures of central tendency, minima, maxima, and standard deviations of samples.
2. Students will recognize that standard deviations cannot be averaged to produce a standard deviation of pooled data.
Strategic
1. Students will be able to apply measures of central tendency to make arguments.
2. Students will be able to suggest missing information when listening to arguments based on (descriptive) statistics.

Communication
1. Students will be able to communicate the meaning of statistics of central tendencies. They will be able to explain what statistics of central tendencies measure.

Learning Outcomes for Voting Power project
Factual/Procedural/Schematic
1. Students will recognize and be able to explain the difference between the number of votes and voting power in a weighted voting system.

Communication
2. Students will be able to explain the Banzhaf power of individual voters from different states in the U.S.
3. Students will be able to communicate quantitative arguments concerning voting power

Learning Goals for Tax Project:
Factual/Procedural/Schematic
1. Students will be able to calculate marginal and effective rates of taxation.
2. Students will be able to identify different types of tax structures (payroll tax, income tax, sales tax) and discuss how such structures affect effective and marginal tax rates.

Strategic
1. Students will be able to (correctly) use the notions of marginal and effective tax rates to critique quantitative arguments about tax policies.
2. Students will be able to (correctly) use the notions of marginal and effective tax rates to suggest tax policy changes.

Communication
1. Students will be able to communicate quantitative arguments using the notions of marginal and effective tax rates.

III. Feedback and Assessment

The following were used to evaluate the results of our project.

• Student Assessment of Learning Gains (SALG) [http://www.salgsite.org/survey](http://www.salgsite.org/survey)
At the end of the semester, students were given, an assignment to complete a post-course survey using the on-line SALG tool. The SALG is a free on-line site on which instructors can create and individualize student surveys designed to obtain feedback on how various elements of the course are helping their students to learn.
Post Tests
At the end of the semester, students took a 12-problem multiple choice post-test. Two of the questions on this post-test were specifically designed to test understanding of material related to the projects. The remaining questions were drawn from the same problem types that Math 102 students in the regular sections of the course encountered on their post-tests.

Copies of Student work on the projects
Copies of project reports/letters from a sample of students were saved and re-read for project evaluation.

In addition, our colleague Blake Mellor made use of the projects with some modifications he introduced. Discussions with Blake both before and after using the projects in class were valuable in evaluating whether the projects achieved their intended goals and in gauging student reaction to the projects.

IV. Teaching and Learning Activities

The collaborative projects were designed to provide students with learning experiences that would focus on collaborative, student-active learning, would engage students in quantitative analysis of current real-world topics, would cause students to interpret the meaning of their results in terms related to the financial, social or other situation from which the problem arises, and would require students to use this analysis to advocate a position on the topic.

Each of the three projects included a component that required students to reflect on the meaning of the mathematics they learned and to relate that mathematics to a real world situation. In the descriptive statistics project, student groups were required to review various descriptive statistics and then to choose which of the statistics to present to the class in order to “sell” their light bulbs. Later, students were given the full data set for all six brands of light bulbs and students discussed which of the six brands is best. In doing this, students had to reflect on the meaning of various statistics, to consider the effect of missing information in arguments based on (descriptive) statistics, to evaluate the appropriateness of using certain statistical measures in various situations, and to see how to make and critique arguments that use descriptive statistics. The final homework requirement of the voting power project required students to calculate the Banzhaf voting power index of an individual voter in each of two states, to consider how this reflects upon the U.S. Electoral College system and then to use this evidence in writing a letter to the editor arguing for or against eliminating the Electoral College. In order to support their arguments, students needed to think carefully about the meaning of the voting power index in this situation. As part of the tax project, students used an Excel spreadsheet to investigate the effects of various possible changes in the tax code. Their final assignment was to write a letter to their congressperson suggesting a change in the tax code to make it fairer. Choosing a suggested change and giving supporting evidence again required students to reflect on the meaning and implications of their mathematical calculations.
V. Integration and Alignment

As mentioned above, in preparing the modules, we looked at a multitude of factors for the course. Of particular situational concern were student attitudes towards mathematics, both in application and in ability. Initially, we had intended for the projects to be used in a version of the course where we only had students with high SAT math scores. Unfortunately, we were unable to create a section of such students. A major learning goal was to have the students discover both the application of mathematics and to synthesize the mathematics so that they could make appropriate presentations of the material.

To integrate these factors and allow for feedback and assessment, we incorporated open-ended group investigations in Math 102 that require students to apply quantitative and analytical skills in addressing contemporary issues. Students had to interpret the meaning of their results in terms related to the financial, social or other situation from which the problems arose, in addition to using the correct quantitative terms. Requiring short reports reinforced written and oral communication skills and/or oral presentations of their results were also required. We then were to collect student assignments (letters to the editor, letters to congressmen, and notes for classroom presentation) for assessment and feedback.

VI. Evaluation of the Course Design’s Impact on Learning and Teaching

After reviewing post-test data and SALG data, we have evidence for two observations. First, post-test data indicated students in the treatment sections finished the course at least as capable of solving basic problems using the course content as students in the traditional sections. Second, a greater proportion of students in the treatment sections reported taking away active reasoning skills from the course as indicated by student responses to the SALG question “What will you carry with you into other classes or other aspects of your life?” Responses from students in the treatment sections were far more likely to answer this question using active language including words such as “thinking,” “reasoning,” and “analyzing” (41% of responses from the treatment sections used active language vs. 11% of responses from the traditional sections).

VII. Lessons Learned/Remaining Questions

The typical Math 102 student found the tax project to be especially challenging because of the open-ended nature of the project. The best students were able to complete the project and produce excellent responses to the project, but the average student struggled to find an effective approach to the project and then struggled to interpret their results. After hearing of our experience with the tax project, Blake Mellor modified the tax project to address these issues before introducing the project to his section of Math 102. The modified version of the project proved to be more tractable for the average Math 102 student. We intend to use the modified version of the tax project in the future, possibly with further modifications.
We will continue to use the projects developed when appropriate and to make these project available to others who teach Math 102 because they provide students with experiences in which they can see how to use mathematics to begin to understand and address the problems of the world in which they live.