IMPACT OF A NEW INTRODUCTORY MATHEMATICAL MODELING COURSE ON STUDENT CONFIDENCE IN MATHEMATICAL ABILITY AND SKILLS

P. DEAN, D. HYDORN, and S. SUMNER
Mary Washington College, Fredericksburg, VA 22401

Interdisciplinary mathematics and science courses are increasing in popularity. Faculty teaching these courses are given the opportunity to show how mathematics plays an important role in science and how it can be used to improve our understanding of mathematics and science. This paper discusses a new course in mathematical modeling that focuses on environmental issues. Course content and format are presented, as well as the results of a study on the changes in students' perceptions of their mathematical abilities as a result of taking this new course.

Introduction

Environmental Mathematics is a new course at Mary Washington College developed under the Virginia Collaborative for Excellence in the Preparation of Teachers (VCEPT) grant. The course was designed for students who are not necessarily mathematics or science majors, but are interested in environmental issues. The developers of the course hoped that the focus on environmental data sets would show how naturally mathematics enters into our daily lives and how it can be used to better understand environmental phenomena. Mathematics is presented as an essential part of science rather than as a separate isolated topic. The course aims to enable students to understand the "mathematical perspective" as they attempt to find solutions and obtain a better understanding of the phenomena they are studying.

Course description

Although primarily a lecture course, class time is allotted for group activities, discussions, videos, and guest lectures. The first half of the semester is spent on families of functions and curve-fitting techniques. Linear, exponential, power, and logarithmic functions are presented along with environmental examples that display the behavior modeled by these functions. The method of least squares is presented, followed by transformations to linearity using logarithms and goodness-of-fit measures. During the second half of the semester, sequences and difference equations are presented as a method for modeling data collected over time. The

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method of undetermined coefficients is presented for solving first-order difference equations that model diverse situations. Mathematical topics also include the logistic function, chaos, fractals, probability models, and patterns in nature. The text for the course [1] covers each of these topics with the exception of probability models.

Various environmental data sets are explored throughout the semester. Population growth and decay, air and water pollution, the use of natural resources, epidemics, genetics, natural disasters, and weather are studied using models from one or both parts of the course. As much as is possible, real data sets from scientific journals are used for class examples and student projects. Although mathematical modeling is presented as a process that scientists use and these students are learning basic modeling techniques, the course follows the pattern for mathematics education suggested by Rublein [2].

Students use graphing calculators and other forms of technology on a regular basis to facilitate model fitting and classroom examples. The TI-82 graphing calculator is used beginning with the first day of class to graph and study data that the students have collected. Calculator use increases in the course as students learn modeling techniques and methods for comparing models. Students become adept at graphing both data and the associated functions and with interpreting their results. In addition to the graphing calculators, the SPSS statistics software is employed as a supplement to graphing calculators for regression and correlation analysis. Two additional software packages, "Fractal Attraction" and "Interactive Differential Equations," are used to enhance the coverage of fractals and chaos.

Student evaluation

In addition to midterm and final exams and regular homework assignments, students complete several writing assignments over the semester. These assignments require students to describe an environmental issue or problem, describe how a mathematical model is used, and what conclusions can be reached. The first assignment requires students to read and summarize an article discussing an environmental issue. Each of the articles contains one or more graphs that students must describe. Discussing the article and describing the graph(s) gives students the opportunity to connect the data with a possible model for the observed relationship and make conclusions about the environment. The topics of articles that have been assigned include sustainable management of tropical forests [3], climate models [4], and population growth [5].

Students complete two group projects that also require a written report of their research and data analysis. These group projects are presented to the class as posters in which students are expected to describe the environmental issue the project addresses and the model they used to analyze the data. The first project involves regression techniques for choosing a best-fitting model. Project topics include monitoring the population size of endangered species [6] and assessing the relationship between the size of harvested trees and their value [7]. The second project requires students to use difference equations to model possible situations involving types of pollution or managing the population size of animals in a wildlife refuge.

Course evaluation

Students completed pre-course and post-course surveys to assess the impact of the course on student perception of their confidence and skill in mathematics. The surveys asked students to indicate the degree to which they agreed with a list of statements. The statements included in the pre-course survey are in Figure 1. Average responses for the Spring and Fall 1998 semesters, as well as the combined results for both semesters, are given in Table 1. Questions for which a paired t-test indicated significant improvement in attitude over the semester are indicated. Although the responses are paired, since pre- and post-course responses were recorded for each student, average responses are given as a basis for comparison. While there are some differences between the two semesters, in general students began the course with attitudes regarding their mathematical abilities that are somewhere between "neutral" and "agree." Both classes showed significant (p-value $< .05$) improvement in students' confidence in mathematical abilities. The class in the Spring semester showed significant improvement in students' confidence in computer skills. Students in the Fall semester showed less significant improvement (p-value $< .10$) in confidence in their calculator skills and in their opinion on their performance on tasks that require the ability to apply information or use analytical skills. No improvement was seen in the Spring semester in these same areas, perhaps due to the fact that those students began the semester with a higher degree of confidence in those areas.

Please indicate in all honesty to what extent you agree with the following statements:
1 = strongly disagree   2 = disagree   3 = neutral   4 = agree   5 = strongly agree
Overall, I would say that I have a high level of confidence in my mathematical abilities.
Overall, I would say that I have a high level of confidence in my computer skills.
Overall, I would say that I have a high level of confidence in my calculator skills.
I typically perform well on tests/assignments that ask me to apply information.
I typically perform well on tests/assignments that ask me to use analytical abilities.

Figure 1. The pre-course survey

Table 1. Average responses for the pre- and post-course surveys.

	Spring 1998 (n = 10)		Fall 1998 (n=13)		Combined	
	Pre	Post	Pre	Post	Pre	Post
High level of confidence in mathematical skills	3.20	3.70**	3.46	3.85**	3.35	3.78**
High level of confidence in computer skills	3.20	3.90**	3.08	3.15	3.13	3.49*
High level of confidence in calculator skills	3.90	4.00	3.31	3.85*	3.57	3.91*
Perform well on tasks that require applying information	3.80	3.80	3.23	3.69*	3.48	3.74*
Perform well on tasks that require analytical abilities	3.70	3.70	3.46	3.77*	3.57	3.74

Key: * indicates significance of the paired t-test for improvement at the 10% level of significance. ** indicates significance at the 5% level of significance.

The post-course survey had two additional questions that measured students' perception of their insight into the integration of mathematics and science and addressed students' understanding of environmental issues. Average responses for both semesters and the combined results are given in Table 2. Responses show that students left the course with the perception that they had gained knowledge about the association between mathematics and science and on issues concerning the environment.

Table 2. Average responses on the post-course survey

	Spring 1998	Fall 1998	Combined
Greater insight into integration of math and science	4.30	4.21	4.25
Better understanding of some environmental issues	3.60	4.29	4.00

Conclusions

Mathematics faculty hope to give their students not only the ability to use mathematics, but also an appreciation of the vital role that mathematics plays in our lives. Of utmost importance is that students develop confidence in their abilities to apply mathematics. The combination of course content and assignments in this new course has resulted in an improvement in students' perceptions of their confidence in their mathematical abilities and improved their knowledge of environmental issues. Student confidence was bolstered by an acquisition of technical and analytical skills as well as an increase in mathematical and environmental knowledge. ■

References

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