TECHNOLOGY-ENHANCED PROJECTS IN AN UPPER-LEVEL MODERN GEOMETRY CLASS

Timothy D. Comar
Benedictine University
Department of Mathematics
5700 College Road
Lisle, IL 60532
tcomar@ben.edu

Introduction

The Modern Geometry course at Benedictine University is populated by mathematics majors, many of whom plan to pursue careers as secondary school mathematics teachers. Most of the students in the course have not studied geometry outside of high school geometry and enter the course with little understanding of how to relate an undergraduate modern geometry to the teaching of high school geometry. One of the projects in this course is directly related to the teaching of geometry. Specifically, students create interactive, guided exercises using the dynamic geometry software package *Cinderella* [3] to illustrate basic geometric theorems. Below, we describe the project, its logistics, and comments about the benefits for pre-service secondary school teachers.

The Project

The students are required to choose a classical theorem from geometry that can be nicely illustrated with the dynamic geometry software package *Cinderella* [3] and to create an interactive exercise in *Cinderella* [3] that enables students either to prove or discover the theorem. Each student is then required to present a complete proof of their theorem and demonstration of their interactive exercise to the entire class in a fifteen-minute talk.

Why Cinderella?

The software package *Cinderella* [3] was selected for several reasons. The primary reason for selecting this particular package is that the user is able to create web-based (JAVA) interactive exercises. This tool is supported by the automatic theorem checking capabilities of the program. The user first creates a construction and then can provide directions, hints, and intermediate steps to help a student arrive at a correct solution. The creation of the interactive exercises makes this project a performance-based assessment, which is strongly encouraged by the Illinois State

Board of Education's Content-Area Standards for Educators [2]. That is, this project not only requires the students to demonstrate mathematical *knowledge* but also to demonstrate the abilities to *apply* and to effectively *communicate* the mathematics in a pedagogically sound manner. Other reasons for choosing Cinderella include its native environments for hyperbolic and elliptic (spherical) geometry as well its inexpensive price. (A school or school teacher could own a single copy Cinderella and export dynamic illustrations and interactive exercises to the web for students to use.)

Project Topics

Three of six students chose to complete this project during the Fall 2001 offering of this course. The selected topics were the Nine-Point Circle Theorem (Coxeter [1], p. 18) Desargues' Theorem (Coxeter [1], p. 238), and the law of cosines in the plane and on the sphere. The first two theorems lend themselves nicely to interactive exercises in Cinderella because they are incidence theorems. The exercise tool can best be programmed to provide feedback for intermediate hints or a complete solution by looking for specific geometric objects, called *input elements*, from the original construction.

The student who worked on the law of cosines uncovered a very important lesson for herself and the entire class: A particular technology may not be the most appropriate platform for presenting a particular concept or illustration. The elliptic (spherical) environment in Cinderella is specifically a two-dimensional environment. The student used three-dimensional vector geometry and relied on the three-dimensional graphing and algebra capabilities of Derive to illustrate the law of cosines on the sphere.

Logistics

The project requires each student to meet with the instructor several times prior to the fifteen-minute oral presentation. During the first meeting, a topic is chosen and approved by the instructor. The second meeting provides a checkpoint for the student to solidify mathematical understanding of their topic and begin preparing the exercises and its presentation. The student presents their report to the instructor a week prior to the in-class presentation to provide the student with feedback and to allow time for reflection prior to presenting their work in the class. Students are evaluated on, in order of importance, mathematical accuracy, organization and clarity of the presentation, demonstrated pedagogical value of the exercise, and performing the reflective process by meeting with the instructor as required.

Benefits for Pre-Service Teachers

The assignment provides the students with an opportunity to develop a practical connection between the geometry which they study as undergraduates and the geometric content which they will teach in secondary schools. As the students choose their own

topics and are required to master a theorem or concept that is not addressed in the classroom, they gain ownership of the mathematical content. The chosen topics are appropriate for an upper-level undergraduate course but are also possible to package for a high school audience. Through this project, the students are expected to develop a sufficiently deep understanding of the mathematical content so that they can effectively communicate the concepts to a high school audience. Moreover, by presenting concepts with interactive, dynamic geometry software, the students gain hands-on pre-service experience with incorporating technology into their pedagogical practice and can develop an appreciation for a dynamic approach to teaching geometry. Two of the students chose to present their work at a local student symposium, which provided a further opportunity to reflect and refine their work as they will do regularly as they embark on their teaching careers.

Acknowledgments

I would like to thank the students of my Fall 2002, MATH 310 Modern Geometry class who completed this project class for their solid, dedicated work on these projects.

References

[1] H.S.M. Coxeter, *Introduction to Geometry, Second Edition*, John Wiley & Sons, Inc., 1969.

[2] Illinois State Board of Education, Division of Professional Preparation, *Content-Area Standards for Educators*, 2001.

[3] J. Richter-Gebert and U. H. Kortenkamp, *The Interactive Geometry Software Cinderella, Version 1.2* (book and CD-ROM with software), Springer-Verlag, 1999.