Math 380: Research Methods in Mathematics

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Introduction

Math 380: Research Methods was developed for Fall semester of 2015 by Dr. Dandrielle Lewis, Dr. Carolyn Otto, and three undergraduate mentors. The main premise of this course is to instruct future mathematicians on the art and procedures of mathematics research. This course prepares students for student/faculty research collaboration at UWEC, readies them for the rigors of graduate study in mathematics, and equips students with skills that will aid in careers in academia or industry.

The class was divided into three units: proof methods, presentation formats and practice, and a final research project. A prominent part of research is the ability to communicate effectively, not only when giving a research presentation, but when working with colleagues. Therefore, throughout the class students were challenged to develop their written and oral communication skills.

Mentor Roles

Three undergraduate students were chosen as "mentors" to develop the class alongside the professors. Two of the three mentors had undergraduate research experience.

Danielle Brushaber and Elizabeth Schwalbach were curriculum mentors, studying Math-Education at UWEC. Their tasks were as follows:

- Assist in organizing the semester schedule
- Develop assignments for the proofs unit
- Create assessment rubrics and grading outlines
- Teach lessons on LaTeX and Beamer

ML Tlachac was the research mentor, studying Mathematics at UWEC, whose tasks were as follows:

- Develop lessons on how to approach the research process
- Model a research presentation
- Aid groups when they reached barriers
- Assist in the process of approving research topics

Student Specifics

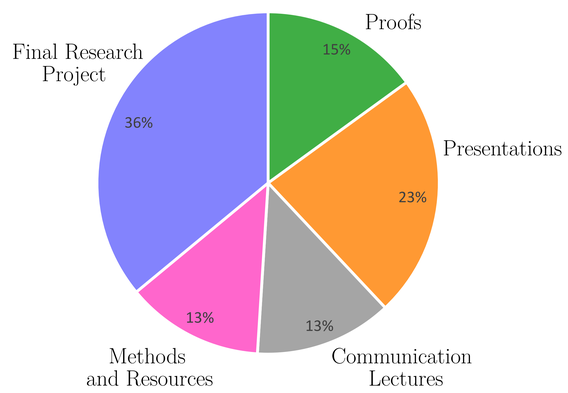
The class was comprised of:

- 5 females, 8 males
- 11 UW-Eau Claire students, 2 UW-Milwaukee students
- 8 seniors, 1 junior, 0 sophomores, 2 freshmen, and 2 undergraduate special students

Distance Learning Component

The class included two students from the University of Wisconsin-Milwaukee. Though some logistical challenges arose, the students at both universities utilized technology such as Skype and ShareLatex to work on projects together. The feedback the students gave was overcoming this distance barrier fit the goal of the class and is something that could arise in their future careers.

Class Time Allocation



Class Structure

The class was divided into three units:

1. Proof Methods
2. Effective Communication
3. Final Research Project

The students participated in a substantial amount of group work and presentations routinely throughout the semester in order to accomplish the overarching goal of developing communication skills for collaborative and presentation settings.

Proof Methods

Since the skill of writing and understanding proofs is so fundamental to mathematics, this was the first topic covered. Students developed proofs from different fields of mathematics utilizing a variety of techniques. Student groups presented proofs to the class to begin their presentation experience.

A final proofs assignment featured direct, induction, contradiction, contrapositive, and multiple case proofs. This assignment was analyzed by the three mentors on the following scale:

Score	Criteria
4: Almost Perfect	1 or 2 grammatical errors, no unnecessary information, no jumps in logic
3: Some Errors	3 or 4 grammatical errors, some mistakes or logical jumps
2: Significant Errors	Began correctly, followed by significant logical mathematical errors
1: Nearly Unreadable	Serious mistakes, extremely difficult to follow, perhaps a proof by example
0: Invalid Attempt	No logic, barely any work

- The average grade on a proof was: 3.4
- Student average grade range was: 2.2 to 3.95
- Problem average grade range was: 3.0 to 3.64

From this analysis, we are confident the proofs unit was successful, especially considering the variety of academic backgrounds.

Effective Communication

The overarching goal of the second unit was to educate our students on the proper techniques of verbal and textual communication used in mathematics research.

To achieve this goalf, several lectures were devoted to various aspects of communication. This unit began with a lesson given by Dr. Lewis on proper etiquette of general presentations, using contrasting examples of correct and incorrect ways to communicate.

Following this lesson, mentors Ellie Schwalbach and Danielle Brushaber taught the common textual medium used in mathematics presentations, LaTeX. An introduction lecture to the concept was given, followed by an individual assignment where students duplicated a page that was created using LaTeX. The lesson to follow was on Beamer (for presentations) and the website ShareLatex.com (for collaboration).

The students averaged one presentation every two weeks throughout the course to practice these skills. The presentations were on proofs, papers, and their own project progress.

Final Research Project

The students concluded the semester with a research project of their own, which encapsulated everything they had learned over the course of the semester. Students were asked to give a 20 minute formal presentation on the research they had done to expand on a preapproved journal article.

Student final projects were titled:

- Musical Actions of Dihedral Groups on Suspended Triads
- A Critique on Fair Division & Redistricting
- The Determinant of Alternating Pretzel Knots
- Containment Partitions
- A Bayesian Approach to Size-Selective Mortality of Certain Species of Young Fish

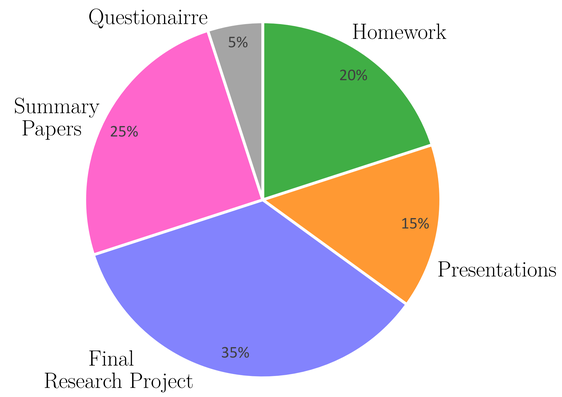
Students were required to create a Beamer presentation to use during a symposium, for which invitations were extended to the Math Department. Additionally, they were required to write either a grant proposal or a formal paper expressing their results.

Progress was routinely presented to the class, and it was a delight to witness the accomplishments in their project and their developing presentation skills.

Future Improvements

Overall, we feel the goals of the class were accomplished, but there can always be improvement. From student feedback, we agree that different mediums of presentations would have been an appropriate addition to the class. For example, the class could include poster making and presenting. The suggestion we, as instructors, deemed appropriate was mentors should be at the same mathematical level or above the students of the class. An obstacle throughout the course in general was the variance of experience in upper level math classes, so we suggest the prerequisites are raised to "completion of Linear Algebra and junior standing."

Grade Allocation



Liberal Education S3 Assessment

At UWEC, we are implementing the new Liberal Education (LE) Core framework which will replace the old General Education framework. The LE Core focuses on students gaining a foundation of understanding within different learning areas: Knowledge, Skills (S), Responsibility, and Integration. The Math 380 course satisfies the S3 outcome: Create original work, perform original work, or interpret the work of others. To assess this outcome, we viewed the final research projects from the course, which fell into one of two categories:

- Students were to write an original piece of work that was 3 to 5 pages. This work was to be based on the papers they read for their research project. They could extend the research done in the papers, and discuss new investigations.
- Students were to write a 3 to 5 page proposal for a potential research project. They would address the relevance of the project and why it is interesting, the purpose of the project, and provide evidence as to why it is attainable.

We assessed two areas

A. Student demonstrates originality and/or creativity in the production or interpretation of work

4 met expectations and 9 exceeded expectations

B. Student demonstrates discipline-appropriate technique

2 met expectations and 11 exceeded expectations

Acknowledgements

- Office of Research and Sponsored Programs, CETL, funded by SoTL.
- Department of Mathematics, UWEC.
- National Science Foundation.
- Graphics rendered using Microsoft Excel and LaTeX.
- Template created by Philippe Dreuw and Thomas Deselaers of Jacobs University: Computational Physics and Biophysics Group, 2007.