

## STLF Report to CWSEI and Mathematics Department

**STLF:** Sandra Merchant

**Period:** 16/05/10 – 01/06/10

**Submitted:** 03/06/10

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### Specific activities performed by STLF

#### 1) Professional development

- Attended the weekly Reading Group discussions (May 19 & May 26)
- Attended the weekly STLF meeting (May 17)
- Attended NOJO meeting #1 (May 26)
- Attended Sam McKagan's talk about the Physics Education Research User's Guide (May 20)
- Met with Wendy Adams to get advice about conducting student interviews (May 18)

#### 2) MATH SEI general meetings/activity

- Attended the weekly Math-CWSEI meeting (May 17)
- Met with Carl, Sarah and the Math STLFs to discuss plans and review our projects. I obtained advice on developing the proof skills diagnostic test. (May 28)

#### 3) Course-specific meetings/activities

##### Tracking Proof Skills Project (MATH 220-Mathematical Proof and subsequent courses)

1. Interviewed Rajiv Gupta, past instructor of MATH 322. The correlation between students' grades in this course and MATH 220 was particularly strong (compared to other subsequent 300-level courses) so we had some discussion about possible causes. Some possible factors are: (1) this course is less computational than most of the other courses (2) the content is built in a more axiomatic manner than the other courses, and (3) this course has a higher ratio of honors:non-honours students, so instructors assume higher ability levels (particularly with regard to abstraction and proof) than in other courses.
2. Began analyzing the student survey results. Some interesting and helpful results so far include (1) students in all sections report feeling least able to do problems that involve constructing sequences and series and testing their convergence/divergence. (2) Students overall report feeling most able to do "proof by contradiction." I found this surprising, and will look at exam problems to determine if they are correct in this and other self-assessments. (3) Although MATH 220 is not a pre-requisite for MATH 300, many students indicated that they found the skills developed in MATH 220 to be useful for this course. This was not on my list of courses to study, but I will look more into the course content (it has some series topics, so this may be why it was mentioned) and possibly also interview instructors of MATH 300.
3. Began interviews of student volunteers to validate the student survey, collect information about how students do the homework and also on their beliefs and expectations upon entering MATH 220 (and if these changed over the term and future years). I have so far interviewed 4 students who volunteered through the web survey, and will now begin to contact students individually to obtain a representative cross-section of the class. These surveys are already proving useful, as it is clear that some of our survey questions need refinement.
4. Developed a few in-class exercises to be used in the MATH 220 fall section.

5. As suggested by Carl, I drew up a draft list of desirable proof skills suggested to me by faculty during my interviews. These are attached to the end of this report. It is my intention to use these proof skills identified by faculty as the basis for course-level and possibly some topic-level learning goals.

### **Current Project Status (material was prepared by either STLF or other members of the MATH SEI group)**

MATH 220:

**Learning Goals:** Faculty interviews are still in progress to compile suggestions for course-level learning goals. Topic-level learning goals will begin this week.

**Assessments:** A student survey has been administered and results compiled. Analysis of the results is still underway.

**New Methods/Materials:** The protocol for student interviews (validation of survey and questions about homework methods and course expectations) has been written. A draft list of proof skills has also been prepared.

### **Plan for immediate future work**

MATH 220:

1. Continue interviewing instructors of related 300-level Math courses for input into course-level learning goals, as well as to determine the amount of proof in these 300-level courses (also examine past final exams to determine this).
2. Begin topic-level learning goals and continue to develop in-class exercises to be used in the fall term.
3. Finish analyzing the results of the MATH 220 surveys and continue student interviews.
4. Continue the literature survey of proof skills and faculty interviews, to expand or refine the list of skills needed to construct and follow proofs.
5. Code student responses on past MATH 220 final exams to identify common difficulties and errors on exams.
6. Continue studying the correlation between student performance in MATH 220 and grades in subsequent courses, including how the focus (proof vs. analysis) influences this correlation.

## Proof Skills Identified by UBC Faculty

The following abilities were identified during my faculty interviews as being essential to constructing and following mathematical proofs. Faculty interviewed include past instructors of MATH 220 - "Mathematical Proof" and subsequent 300-level courses, including MATH 308, MATH 312, MATH 320, MATH 322 and MATH 342.

\*This list is not complete, since interviews are still in progress. Here I am using (as closely as possible) the original wording given by faculty. In some cases, related "sub-skills" are listed below an item.

1. Identify theorems and lemmas that may be useful for the proof.
2. Identify or give corollaries (consequences) of a theorem or statement.
3. Find counterexamples to show a statement is not true.
4. Identify/give/recall relevant definitions.
5. Convert statements to equivalent statements using logic.
6. Determine the set of objects the theorem or statement is about (ex. Real numbers, integers, continuous functions, symmetries of a polygon, etc.).
7. Determine if something is a proof or not (i.e. Does it prove the statement?).
  - Use logic to determine when statements are true or false (especially conditional statements)
8. Make educated guesses whether or not a statement is true (i.e. "intuition").
  - Remember similar results/problems
  - Do some simple tests/counterexamples ("simple" can be domain specific)
9. Rank various methods of proof by (expected) usefulness for a problem.
  - Choose an approach
  - Recall indicators for what methods may be most fruitful (ex. Type of quantifiers, mathematical domain (ex. analysis vs. algebra vs. number theory), remember proofs of similar statements, others?)
10. Identify the assumptions in a theorem/statement.
11. Identify the conclusion in a theorem/statement.
12. Convert statements to equivalent statements using definitions
13. Draw a conceptual picture of the theorem/statement.
14. Give an example that illustrates the theorem/statement.
15. Recognize what assumptions were used in proving a theorem and which were not:
  - Explain why the assumptions are required/recognize what part of the conclusion does not hold if an assumption is removed or relaxed

- Give an example illustrating how the conclusion is false if an assumption is not satisfied.

16. Remove unnecessary assumptions in a theorem/statement.

17. Remove/combine unnecessary steps in a proof using properties, lemmas and theorems.