STLF Report to CWSEI and Mathematics Department

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Specific activities performed by STLF

1) Professional development

- Attended the weekly CWSEI Reading group meetings.
- Attended the weekly STLF meetings.
- Met with Brett Gilley for our MetaSTLF meeting (Oct 19).
- Help to organize and attended the session "Interactive Engagement in Large Classrooms: Methods and Examples from the Carl Wieman Science Education Initiatiative" during Celebrate Learning Week (Nov 2).

2) MATH SEI general meetings/activity

- Met with Director Costanza Piccolo and the MATH-SEI group to review the status of our projects (Oct 17, Oct 24, Oct 31).
- Met with Sarah Gilbert and the MATH-SEI group (Oct 10) to review the status of our projects.
- Selected and summarized the paper "Expert and Novice Approaches to Reading Mathematical Proofs" by Matthew Inglis and Lara Alcock, for this month's math education research reading group (Oct 26).

3) Course-specific meetings/activities

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

1. I have furthered analyzed the results of the basic proof skills diagnostic test administered in Math 320 on Sept 12. I have previously reported on retention of skills by Math 220 students, as well as a comparison of skills between Math 220 students and "no-Math 220" students, by looking at their performance on the full test. I have now examined these on a question-by-question basis. Two results have been found:

   Result 1: Skills of the "Math 220 stream" students differ from those in the "no-Math 220 stream"

   Overall, students who had taken Math 220 performed better on the diagnostic than those who did not ($p<0.001$). However, on a question-by-question basis, there is only a significant difference on a few problems. These differences are shown in the following table:

Question number and type of material tested	**Math 220 Stream (N=44) Number Correct**	**No-Math 220 Stream (N=43) Number Correct**	**Chi-square test P-value**
Q3: Precalculus material, graphing	23	10	0.00001
Q6: Mathematical quantifiers	36	25	0.003

Q13: Proof comparison	39	31	0.003
Q14: Mathematical definition	30	22	0.04
Q16: Mathematical definition	21	14	0.04

As we can see here, in all of these cases the Math 220 students performed better than the no-Math 220 stream. The better performance on Q3 is a mystery to me, as this material is not explicitly addressed on Math 220. The better performance on the remaining questions, however, may be a consequence of these concepts being standard coverage in Math 220.

Result 2: Retention of the various skills on the test.

Viewed as a whole, we found that for the 27 students who took the diagnostic test in both courses their scores were essentially unchanged from the Math 220 post-test to the Math 320 start-of-term test, suggesting that retention of these skills is good. However, it may be instructive to examine the fluctuation between the two tests on a question-by-question basis, as it is possible that students lost some skills but picked up others. I examined this and found that for all questions, except Q4, on the test there was no significant change in the fraction of correct responses. This suggests that perhaps all of these skills are retained equally well. However, I did find that some problems (ex. Q1-Q4, multiple-choice on pre-calculus material) had a substantial amount of fluctuation (ex. 5 students switched from incorrect to correct, while 5 students switched from correct to incorrect), with a net change of zero. Alternatively, some questions had no changes in either direction. I will look into this further, as it may suggest that some concepts behave as "threshold concepts" in that learning of these is difficult, but once attained is largely irreversible.

2. In addition to proof skills we also aim to track student attitudes towards proof and mathematics in general in Math 220 this term and next term, in order to assess whether there are differences between standard lecture and interactive engagement formats. This assessment will consist of the math attitudes and perceptions survey (MAPS), as well as some specific survey questions about attitudes towards reading and writing proofs, and will be administered at the end of the term.

3. Unfortunately, I have not had time to do any more work on the higher-level "proof concept test." At this stage we have a draft of the first (open-ended) version of the test, but I still need to solicit feedback on the test from faculty members who teach proof-intensive courses.

MATH 102 (Differential Calculus with Applications to Life Sciences)

1. Work continues on developing online homework, labs and pre-lecture quizzes for this course (typically 3 quizzes, 1 lab and 1 homework set each week). As the end of term approaches, I will begin working on documenting lessons learned and changes recommended for future terms.

2. Together with Costanza Piccolo, we are conducting a study skills intervention and associated research project in this course. Much of the planning was done jointly with Sara Harris, Jackie Stewart, Ashley Welsh and Laura Weir, as similar interventions were planned for several courses. We selected all students who scored 63% or less on the first midterm and sent them an email inviting them to one of two study skills workshop. The workshop consisted of three

small group activities, as well as some general study advice for this course (presented by the STLFs). The first activity was an icebreaker. Students were asked to discuss with their group what they did to study and what they found useful, or not useful, etc. The second activity consisted of aligning study materials (the course notes) to midterm questions. The third activity was an in-depth examination of a worked solution from the course notes, with metacognitive prompts to be answered by the groups. Based on our observations and feedback from the students, the first and third activities seem useful, but we would consider changing the second activity in the future. The workshop materials were made available to all students in the course on the course webpage.

In total 26 students attended the workshops, which includes roughly half of the low-scoring students targeted for the intervention. Feedback for the study skills workshops was quite postive. We look forward to seeing if they have any substantive impact on performance on the second midterm, which takes place Nov 6th.

3. The course forum continues to be very active, with 757 posts so far, and an average response time of 48 min. However, during our study skills workshops, asking or answering questions on the course forum was reported by students as one of the least useful study strategies. We have planned after the term ends to analyze usage of the forum, and I think during this we should consider the forum's purpose. In particular, it may be useful in future terms to give some guidelines to students for effective use of the course forum.

Math Attitudes and Perceptions Survey (MAPS) – joint work with STLFs Warren Code and Joseph Lo

1. We still need to conduct a few more student validation interviews before soliciting expert responses to the current version of the survey. We plan to complete these validation interviews soon.

2. The survey was administered in a range of courses at the start of the term. In order to get a higher response rate, we offered a draw for a gift card. Nevertheless, we were still only able to attain the usual 30% response rate for most of the courses.

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

MATH 220:
Learning Goals: Learning goals have previously been created for this course and are in use.
Assessments: The basic proof skills diagnostic pre-test was given at the start of term. The results still need to be compiled and analyzed. A proof concept test is in development to assess higher-level proof skills.
New Methods/Materials: None.

MATH 102:
Learning Goals: Costanza Piccolo is currently working on learning goals for this course.
Assessments: None yet.
New Methods/Materials: A series of online pre-lecture quizzes is being created. Weekly online homework sets are being created. Labs for the course are being substantially modified. We have created a study skills workshop specific to this course.

Plan for immediate future work

MATH 220:

1. Continue working on our paper about the basic proof skills diagnostic.
2. Analyze the basic proof skills diagnostic results for both sections of Math 220 and compare with previous terms.
3. Make a plan for getting experts to complete the basic proof skills diagnostic to provide further validity (how do experts score on the test?).
4. Perform student validation on the portions of the basic proof skills diagnostic that have not been validated.
5. Create a short survey for attitudes towards reading and writing proofs.

Higher-Level Proof Courses (MATH 320, and MATH 312)

1. Track the performance of students in Math 320 and compare with their performance on the basic proof skills diagnostic, as well as their Math 220 grade (when applicable).
2. Get feedback from several faculty members on the proof concept test.
3. Pilot the draft test in think-aloud interviews with students from Math 312 and revise the test as needed.

MATH 102

1. Continue to create pre-lecture quizzes and weekly problem sets in WeBWorK.
2. Continue to assist with the revisions of the course labs.
3. Continue to monitor the student forum, and keep track of difficulties and misconceptions that are discussed there.
4. Examine how students performed on midterm 2 for evidence of whether the study skills intervention was successful.

MAPS

1. Examine the responses from Math 220 students, and compare these with responses we have from first-year calculus courses.
2. Continue student validation interviews.
3. Publish the validated version of the survey online and solicit responses from experts (goal of 50 expert responses).