

Dear WDI Committee,

Please find the amended proposal below. For your convenience, I have highlighted changes and additions in red. Alternatively, I believe I can better address your comments directly.

1. *As your proposal covers two different courses, made up of quite different groups of students, we request that you discuss its utility for both groups. Much of your discussion in the proposal seems to focus on the needs of students in MAT223; we suggest that you discuss how it will benefit students in MAT133 as well, most of whom would be planning to pursue Economics or Management.*

The goal throughout the project is to improve upon students' technical written communication abilities. The core skills developed -- explicit definitions, clarity of exposition, use of diagrams, sequential reasoning, anticipation of problem points -- translate to all technical communication irrespective of subject matter. There will be different expectations for both courses, as the material and mathematical maturity expectations differ correspondingly, but the overarching goal for both courses coincide. The utility therefore is universal to both courses, and I hope this clarifies things.

I suspect that the perceived bias towards MAT223 was caused by the paragraph starting "Mathematics communication is generally recognized as a critical, but under represented skill amongst technical experts." This paragraph focuses on a mathematical example as it is the font from which my personal experience flows. However, it was not my intent to draw particular attention towards advanced mathematics. It has been removed, and I have focused that section on the broad goal of technical communication.

2. *To judge by the research literature that you reference, the PAR approach that you plan to take does not necessarily or explicitly target writing skills. We invite you to clarify its connection specifically to student writing.*

An excellent point. Peer-Assisted Reflection was developed with an ancillary goal of improving student explanation and communication, but its effect on writing was not quantitatively measured as part of the seminal paper. I was remiss to exclude the following piece of literature which clarifies your concern:

Calkins, S and Grannan, S and Siefken, J. Using Peer-Assisted Reflection in Math to Foster Critical Thinking and Communication Skills, PRIMUS, DOI:10.1080/10511970.2019.1608608

This paper explicitly looks at the use of PAR in writing. The lead author Jason Siefken (Mathematics papers are always alphabetically arranged) is a teaching professor at the St. George campus. Through consultation with the literature, Dr. Siefken, and the mathematics writing team at the St. George campus, it was determined that PAR is uniquely qualified to assist in developing technical writing skills in students.

3. *Your project targets students' ability to communicate mathematical concepts to peers. We invite you to briefly justify this choice of audience, rather than e.g. a more general audience.*

Communicating to a lay-audience is also a degree level expectation of the department for all programs and service classes. Informally, we believe that in the nascent stages of the program it is better to focus on one form of communication rather than divide our attention. The choice for peer communication over any other audience is owed to the balance of literature on the topic, as well as the motivation that the majority of a student's university writing will be of the technical type.

Writing Development Initiative
2020-2021 Proposal Application Form

1. Please indicate the course code:

MAT133Y5 and MAT223H5 (both F and S)

2. Please briefly (150 words maximum) introduce the course, its position in its program, and writing assignments or instruction that have typically been used.

MAT133Y5 (Calculus and Linear Algebra for Commerce) is a service course offered by the Department of Mathematics and Computational Sciences (MCS). It is directed towards students pursuing programs in Economics and Management, and is assumed to be a terminal course for students in these programs.

MAT223H5 (Linear Algebra I) is a core course within the MCS department, and is required for every major and specialist program in each subdepartment (Mathematics, Computer Science, Statistics). It is also required for students enrolling in the Economics specialist program. While listed as a 200-level course, MAT223 is often taken in first year.

To date, there has been no dedicated effort to writing assignments or instruction in either course. In the 2019-2020 academic year, MAT133Y5 made an effort to enhance student writing through a clear set of expectations, assignment feedback, and marking. While we believe that the effort was successful, we are certain that a dedicated effort would greatly expand upon this success.

3. Please indicate the desired learning outcomes for the proposal (as distinct from the course as a whole), and how these learning outcomes relate to the course or program's learning outcomes: that is, indicate how the proposal complements student learning viewed holistically.

Students should be able to clearly, concisely, and accurately communicate mathematics to an audience of similar technical proficiency. For our purposes, such an audience represents other students in the same course, and instructors (for the purpose of grading).

When communicating to a technical audience, our goal is that student writing clearly demonstrates competency with the material and conveys understanding. This includes accurate use of terminology, clear definitions, and explanations, but also soft skills such as the ability to anticipate points of confusion, creating diagrams to assist in demonstration, and to assess what information is unnecessary to provide a complete and satisfactory explanation.

Technical communication is generally recognized as a critical, but under represented skill amongst experts. **Mathematics communication represents an extreme of the spectrum, wherein a set of concrete rules and logic defines the progression of an argument. Nonetheless, the core skills mentioned above translate to any example of technical communication, irrespective of subject matter.**

Departmental degree learning expectations (DLEs) include student competency in writing for both technical and lay audiences. While the program will eventually expand to include lay audiences in the future, we have chosen to focus on technical audiences for two reasons:

- a. The body of pedagogy research regarding technical, peer-based communication is more thoroughly developed in mathematics.**
- b. The majority of a student's writing throughout their university career will be technical communication.**

4. Please provide a basic overview of the strategies that will be used to improve students' writing.

Mathematics writing is not discussed in the high school curriculum, and as a result, students are often unaware of what constitutes rigorous reasoning and clear communication. Common student solutions in first year mathematics courses frequently consist of a mindless expulsion of randomly organized work, with no semblance of explanation, coherence, or an attempt at communication. This is because students do not believe that their objective is to communicate their work or understanding, but to arrive at the final answer. However, when students are forced to read the work of other students, they quickly identify that such solutions are unsatisfactory.

Both courses will make use of Peer-Assisted Reflection¹ (PAR) as a writing

¹ Reinholz, D.L. Peer-Assisted Reflection: A Design-Based Intervention for Improving Success in Calculus. *Int. J. Res. Undergrad. Math. Ed.* **1**, 234–267 (2015).

technique. PAR was specifically developed to enhance **written communication** skills in mathematics classes, and preliminary evidence supports student gains in class-specific learning objectives to be on par with other evidence based interventions. **Specifically, PAR has been shown² to improve upon “... student’s ability to evaluate mathematical arguments and communicate those evaluations in writing.”**

In a PAR assignment, students create drafts of solutions, reflect on those solutions individually, exchange feedback with another student, and revise their work before submitting. We will expand on this process more in Section 8 below.

- 5. Starting in September 2020, UTM will begin offering a first-year writing course, ISP100H5 Writing for University and Beyond: Writing About Writing. For the 2020-2021 school year, this course will be required by the Departments of Anthropology, Chemical and Physical Sciences, and Visual Studies for admission to some of their Specialist and Major programs. If you are proposing a project for a first-year course in any of these Departments, please be sure to consider how the project would complement or reinforce instruction offered in ISP100H5. For further details about ISP100H5, please contact Michael Kaler (michael.kaler@utoronto.ca).**

Not applicable

- 6. Please indicate how Teaching Assistants will be used in the project.**

As there are several courses involved, we propose the creation of a Lead Writing Teaching Assistant (LWTA), who will be central to the writing project and course independent. The responsibilities of the LWTA will include

- a. Consultation in development of PAR assignments.
- b. Providing math-writing specific training to course TAs.
- c. Running “benchmarking” sessions with TAs prior to marking PAR assignments. These are sessions where the LWTA gathers with the course TAs, and moderates a discussion over marking the PAR assignments. This includes reviewing several papers and determining a rubric. It also includes follow up on marking to ensure consistency and accuracy.
- d. Assisting in the administration of PAR assignments.

² Calkins, S and Grannan, S and Siefken, J. Using Peer-Assisted Reflection in Math to Foster Critical Thinking and Communication Skills, PRIMUS, DOI:10.1080/10511970.2019.1608608

The LWTA will be chosen as an experienced, senior graduate student who will ideally take on the role for several years. We plan to expand this project to other first year courses in future years, in which case the LWTA will play a central role in the scalability of and sustainability of the project.

Course TAs will be responsible for marking PAR assignments, and additional hours will be required for this.

- 7. Please indicate whether additional TA training (beyond the WDI Writing TA Training session for new TAs) will be required and, if so, indicate the number of hours/TA (maximum 4), content of the training, and its relationship to the proposed student assessment or instruction.**

The role and responsibilities of the LWTA will require additional training in regard to discipline specific writing. As mentioned previously, the lack of emphasis on writing in mathematics means that even experienced and well-performing graduate students lack writing skills.

Our understanding is that the analogous LWTA position at UTSG receives 15 hours of training from the Writing-Integrated Teaching program. We anticipate a similar level of training. However, we ideally will be hiring a student interested in maintaining the same role over several years, meaning that this may be an infrequent expenditure.

- 8. Please describe the writing tasks incorporated as a direct result of the additional funding requested, and provide details on any writing instruction to be provided that relates to these tasks. If the funding is supporting an increased number of graded writing assignments, please indicate the number of additional words students will write.**

Students in both MAT133Y5 and MAT223H5 will be submitting PAR assignments. Specifically, the PAR method consists of five steps:

- a. Students are provided with a problem which they will submit for marking, and asked to draft a solution to that problem. The first draft is written outside of classroom time. The audience for this problem consists of other students from the course, and indeed the draft will be read by another student shortly.
- b. Students are asked to reflect on their own work shortly after writing their draft. We provide several simple and concrete checkpoints that a student

should verify have been included (defining variables, including explanations, showing work, etc), followed by softer skills on which the student can reflect (accuracy, clarity, reasonableness of the solution, etc).

- c. Students will provide feedback on each other's papers as follows:
 - i. Lectures which precede the deadline for a PAR assignment will begin with a 10 minute "training" session, where sample solutions are projected to the front of the room. As a class, we discuss potential feedback, and what types of feedback are valuable.
 - ii. Students pair up (randomly), exchange solutions with one another, and are given 5 minutes to provide written feedback. At this stage, there is no discussion between students.
 - iii. Each student is then given 5 minutes to explain their feedback to the other student (hence 10 minutes is required for this portion).
- d. On their own time, students use the feedback provided to revise their draft solution into a final solution.
- e. Students submit their final solution for marking.

In these questions, our goal is primarily to assess the quality of the explanation, with the validity of the mathematics playing a secondary role. The PAR engages students as both givers and receivers of feedback, and by having students read the work of other students, they come to realize what constitutes good writing.

- 9. Please clearly state the number of students participating in the project, if the proposed project is course-based. Indicate the maximum enrolment for the relevant course(s) and the final enrolment in the courses the last time they were offered. Please also indicate the course's relationship to the broader program of study.**

MAT133Y5Y - Max Enrollment 660, Initial Enrollment 575, Final Enrollment 313
MAT133Y5 is a terminal course, in service to the Economics and Management departments. It is designed for students interested in pursuing degrees in Commerce, Managements, and Economics.

* Note that while MAT133Y5 has historically always had a high attrition rate, the majority of students remain in the course until the drop deadline. The drop deadline occurs after Week 6 of the Spring Term, or 75% of the way through the administration of the course. Moreover, PAR has been shown to increase retention rates amongst students.

MAT223H5F - Max Enrollment 520, Initial Enrollment 515, Final Enrollment 466

MAT223H5S - Max Enrollment 520, Initial Enrollment 494, Final Enrollment 449
MAT223H5 is a core course in the MCS department, and is required in every major and specialist program. It is also a required course for students in the Economics specialist program. While listed as a 200-level course, it is often taken in first year.

Total - Max Enrollment 1700, Initial Enrollment 1584, Final Enrollment 1228

In both courses, the initial enrollment of students tends to remain in the class until the drop deadline. In MAT133Y5, the drop deadline occurs 75% of the way through the course. The 75% initial weighted average of the difference between the initial and final enrolments of MAT133Y5 is 510 students. Similarly, the drop deadline for MAT223H5 occurs 66% of the way through the course. The 66% initial weighted average of the difference between the initial and final enrollments of MAT223 is 971 students. Therefore, the drop deadline-balanced average number of students 1481 students.

10. Please provide details on how the funded activities will impact and support students, if the proposed project is not restricted to a specific course (or courses).

While the funded activities are course specific, we would like to take this opportunity to discuss the purpose of this project.

As mentioned, mathematics writing is a critical component of learning mathematics, and learning to communicate technical writing. The mathematics department is going through its curriculum renewal process, and has proposed that writing be an explicit Degree Level Expectation of our program. We hope that this WDI application will represent the pilot in a program which will expand across the entire collection of first year mathematics courses.

11. Please indicate any other resources you will use to support your project (library, RGASC, online resources, etc.).

We expect that both the Writing and Numeracy Specialists at the RGASC will be essential in getting the program off the ground, and in training our TAs. Beyond this though, all required resources are course dependent.

12. Please provide a detailed budget.

MAT133Y5Y - PAR assignments

Description (Number)	Hours	Cost (at \$50/hour)
Benchmarking Sessions	10 TAs x 4 sessions x 1 hours = 40 hours	2000
Marking PAR Assignments	7 minutes per assignment x 510 students* x 4 assignments = 240 hours	12000

* - based on drop-deadline average of students

MAT223H5F - PAR assignments

Description (Number)	Hours	Cost (at \$50/hour)
Benchmarking Sessions	10 TAs x 3 sessions x 1 hours = 30 hours	2000
Marking PAR Assignments	7 minutes per assignment x 485 students x 3 assignments = 170 hours	8500

* - based on drop-deadline average of students

MAT223H5S - PAR assignments

Description (Number)	Hours	Cost (at \$50/hour)
Benchmarking Sessions	10 TAs x 3 sessions x 1 hours = 30 hours	2000
Marking PAR Assignments	7 minutes per assignment x 500 students x 3 assignments = 170 hours	8500

* - based on drop-deadline average of students

Lead Writing TA

Description (Number)	Hours	Cost (at \$50/hour)
Additional Training	8 hours	400
Benchmarking Sessions	1 hour x 10 sessions = 10 hours	500
Development	10 assignments x 2 hours = 20 hours	1000

Administration	10 assignments x 2 hours = 20 hours	1000
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Total: 738 hours, \$36900. This amounts to (27.9/36.1/29.9) minutes and (\$23.30/\$29.97/\$24.68) per student, based on initial, final, and drop deadline-balanced average,³ number of students respectively.

13. Please include this sentence in your application: “I confirm that I approve this proposal.”

I confirm that I approve this proposal.

14. Please also include this sentence in your application: “I confirm that my Chair supports this proposal.”

I confirm that my Chair supports this proposal.

³ See the end of Section 9 for this rationale and computation of 1481 students.