



Teaching first-year math students to love doing math: Shifting from calculations to creativity, critical thinking, and community

Caroline Junkins, McMaster University, Canada

Jessie Meanwell, McMaster University, Canada

Difei Zheng, McMaster University, Canada

Lee van Brussel, McMaster University, Canada

ABSTRACT

To support the transition to university-level mathematics, McMaster University has developed the McMaster Peer-Run Inclusive Math Experience (MacPRIME), a four-week online bridge program designed to emphasize the importance of creativity and critical thinking in mathematical problem-solving while building community among incoming first-year participants. The MacPRIME model uses cascading near-peer mentorship and curricular co-creation over a year-long cycle that consists of planning, designing, facilitating, and reflecting. Throughout this cycle, various forms of mentorship take place between the faculty supervisor, undergraduate student leaders, and participants, with each taking turns as both mentor and mentee. During the program itself, student leaders guide participants through digital activities which they have designed to integrate mathematical concepts with evidence-based learning strategies and advice for navigating student life. Participants find the program to be valuable to their first-year experience, and their feedback has led to improvement and refinement across cycles. In this vignette, our goal is to provide a glimpse into each of the four seasons of the MacPRIME model, focusing on the interconnected flows of co-creation, growth, and mentorship.

Keywords: summer bridge program, near-peer mentorship, curriculum co-creation, math education, student development

Introduction

Each year, approximately 300 first-year students enter the Mathematics & Statistics Gateway program at McMaster University, a public research university in Ontario, Canada. While all of these students share a common goal of pursuing an undergraduate degree in the mathematical sciences, we find that many are surprised at how different the process of ‘doing math’ becomes at the tertiary level, when the emphasis shifts from rote memorization and cookie-cutter problems to theory, proof-writing, and challenging applications. As a result of this shift, many first-year students struggle in their courses or start to believe they have chosen the wrong program. To help incoming students navigate this transition successfully, we developed the McMaster Peer-Run Inclusive Math Experience (MacPRIME), a four-week online bridge program offered the summer before students enter the Math & Stats Gateway. The program was piloted in 2022 with 48 participants completing all 4 weeks. In subsequent years, completion rates remain within 15-18% of the incoming cohort.

MacPRIME operates using a cascading near-peer mentorship model (see Figure 1), similar to models that have been successful in Medical Education (Ramani et al., 2016; Patel et al., 2021), but with the additional element that all curriculum for the program is co-created through partnership between students and teachers at different ‘levels’ of the mentorship model. This form of co-creation has been used in Engineering (Tripathy et al, 2022) and Social Sciences (Seery et al, 2021) and is aligned with evidence-based instructional practices in Undergraduate Mathematics (Mathematical Association of America, 2018). The process of planning, development, facilitation, and feedback takes place over a full calendar year, with the leadership team (one faculty supervisor and three undergraduate student leaders) working collaboratively and mentoring one another in different ways at each stage.

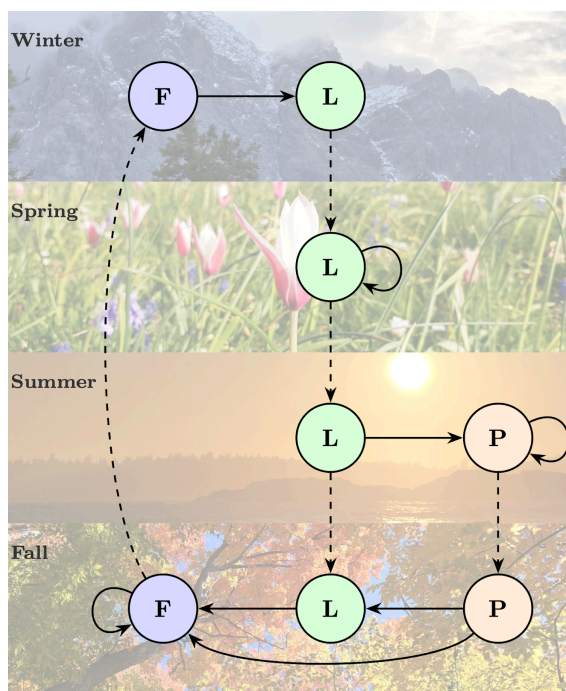


Figure 1 SEQ Figure * ARABIC 1 Overview of the model, illustrating the various flows of mentorship (solid lines) and growth (dotted lines) between the faculty supervisor (F), undergraduate student leaders (L), and participants (P)

The MacPRIME mentorship and co-creation model

Winter (planning): What do we want students to learn?

Over the winter, the leadership team meets weekly to develop curriculum for the upcoming program cycle. We start by asking ourselves “What do you wish you had known in your first year of Math & Stats?” Emerging themes include the importance of community, collaboration and play—that math is fun, and most fun when working with others. Responses also emphasize the critical thinking required in university-level problem solving, and the value of productive struggle and growth mindset (c.f. Dweck, 2013; Hiebert & Wearne 2003). Alongside these cognitive and metacognitive strategies, we also want to introduce participants to on-campus and digital resources such as office hours, mathematical technology, and

Teaching first-year math students to love doing math: Shifting from calculations to creativity, critical thinking, and community

undergraduate organizations. By openly discussing the norms and expectations that govern interactions among students and faculty at our institution, we expose parts of the hidden curriculum in higher education (Ahola, 2000).

At this stage in our mentorship framework, the faculty supervisor takes the lead by introducing the development goals for the year to the student leaders, based on feedback from the participants from the previous cycle and guidance from past student leaders. For example, in the 2022 cycle, we noted an underrepresentation of international students and aimed to address this gap in 2023. The student leaders learn from each other by reviewing the existing curriculum and brainstorming possible changes.

Spring (design): Building and refining our program activities

Using the process of backwards design (Wiggins & McTighe, 2005), the leadership team works together in spring to construct activities for the program. Each activity centers on one mathematical concept and one McMaster-related learning objective and is hosted on Amplify Classroom (formerly Desmos Classroom), a free web-based instructional platform (Amplify Education, 2025). While a single student leader takes the lead on one activity, the full leadership team collaboratively refines it through several rounds of feedback.

Each activity began with clear learning objectives, classroom norms, and an icebreaker, followed by a main activity to be completed by participants in breakout rooms, and concluded with a wrap-up and participant feedback. The main activity is designed to integrate each of the week's learning objectives in a student-centered active learning framework. For example, the Week 1 activity has participants work in pairs to draw paths between buildings on a campus map using mathematical functions. Pairs then share their work with others, showcasing a variety of approaches and challenges. This activity supports both the review of high school math skills and the introduction of practical knowledge needed to navigate their first days at McMaster.

At this stage in our mentorship framework, student leaders expand their pedagogical approaches and bring their vision for MacPRIME to life. The faculty supervisor provides weekly guidance to ensure the activities are engaging, inclusive, and accessible to all future participants.

Summer (facilitation): A week in the program

During each week of the 4-week summer program, a participant attends one required group meeting and up to two optional supplementary sessions. During the group meeting, their student leader facilitates a zoom session with 10-15 participants using the week's activity on Amplify Classroom. Using the teacher dashboard within the platform, the student leader monitors participants' progress in real time, joins breakout rooms when participants need support, and shares examples of student work with the full group. Throughout the program, we emphasize the value of friendship to navigate the transition to university together and are pleased to see participants connecting and collaborating.

Supplementary sessions were introduced in the program's second cycle in response to participant feedback requesting more ways to interact and meet others outside of weekly group meetings. Open to all participants, these sessions span mathematical and university-related topics, including a proof-writing workshop, guidance on choosing first-year courses and reading the course calendar, and a Q&A panel where former student leaders returned to share their experiences in academia and industry. The supplementary sessions were immediately popular and are now a key component of the program.

Teaching first-year math students to love doing math: Shifting from calculations to creativity, critical thinking, and community

At this stage in our mentorship framework, the faculty supervisor works entirely behind the scenes, providing continuous support to the student leaders rather than direct instruction to participants. The student leaders apply what they learned in the spring, developing their own mentorship and teaching styles as they work with participants. Student leaders also support each other by sharing reflections from their meetings, including practical tips and warnings. At the end of each week, the full leadership team meets to debrief, reflect on the week's successes and challenges, and prepare for the following week.

Fall (reflection): Collecting feedback to improve our teaching

A few weeks after first-year students arrive on campus and take part in university-wide welcome events, the MacPRIME leadership team hosts an in-person event for participants and alumni of the program. To encourage attendance, we provide pizza and games, and invite participants to bring a friend. This event allows participants to connect with each other in real life, as well as to meet other first-year students who did not participate in the program.

Throughout the fall, we are delighted to see MacPRIME participants working collaboratively in their courses, forming study groups and friendships. When surveyed, participants consistently share that MacPRIME helped them understand how to use resources and reflect on their learning process, and that they would recommend the program to future students. We also follow up individually with participants to learn from their experiences and identify areas for improvement. When we open student leader applications for the next cycle, we encourage alumni of the program to step into these leadership roles. Current student leaders are encouraged to apply for positions as teaching assistants for first-year calculus courses, giving them an opportunity to further hone their teaching skills, and providing participants with a familiar face in the classroom.

At this stage of our mentorship framework, the strong relationships built between student leaders (now teaching assistants) and participants (now first-year students) encourage open dialogue. Participants more readily share feedback about MacPRIME and the Math & Stats Gateway program with their near-peer mentors. Student leaders relay this first-hand feedback to the faculty supervisor, who can adjust departmental teaching approaches to better meet students' needs and support their learning.

Conclusion

The ultimate goal of the MacPRIME program is to support student success by encouraging students to adopt new ways of approaching mathematics. The full-year model reflects the reality that shifting mindsets and changing behaviour patterns are difficult tasks (c.f. Sisk et al., 2018), and that the 4 weeks spent by participants in the program itself are not a 'quick fix', but rather an invitation for students to begin the real work of building connections and emphasizing creativity and critical thinking in their work. The student leaders are invaluable to accomplishing this goal as they bring viewpoints not accessible to faculty. Curricular co-creation leverages their lived experience and close connection to both academic material and student life, while the cyclical nature of MacPRIME allows for continual refinement. In the interactions that take place between the faculty supervisor, student leaders, and participants, we see not just a typical top-down cascade of mentorship, but also circular eddies where student leaders and participants mentor one another, as well as reversing tides where student leaders and participants bring vital feedback and insight to the faculty supervisor.

Biographies

Caroline Junkins is an Assistant Professor in the Department of Mathematics & Statistics at McMaster University. Caroline's research in Tertiary Math Education focuses on using data-driven techniques to understand and improve student learning. Caroline is the founder of MacPRIME and was the MacPRIME Faculty Supervisor in 2022 and 2023.

Jessie Meanwell is an educational developer and artist. Jessie holds a Masters of Science from McGill University and a Bachelor of Science (Honours) from McMaster University, both in Mathematics, and has experience as a teaching assistant and mentor for various programs. Jessie was a MacPRIME Student Leader in 2023.

Difei (Fay) Zheng is a Master Candidate in Medical Sciences at McMaster University. Fay holds a Bachelor of Health Science (Honours) from McMaster University, with a minor in Mathematics, and has experience as a Teaching Assistant and Clinical Research Assistant. Fay was a MacPRIME Student Leader in 2023.

Lee van Brussel is an Assistant Professor in the Department of Mathematics & Statistics at McMaster University. Lee's mathematical research lies in applied analysis, and he is also active in accessible education, aiming to make math courses more approachable for all students. Lee was the MacPRIME Faculty Supervisor in 2024.

References

- Ahola, S. (2000, August 30–September 2). *Hidden curriculum in higher education: Something to fear for or comply to?* [Paper presentation]. Innovations in Higher Education Conference, Helsinki, Finland. University of Turku. <https://www.utu.fi/sites/default/files/public%3A/media/file/HCArticle.pdf>
- Amplify Education, Inc. (2025). *Amplify Classroom* [Digital teaching and learning platform]. <https://www.amplify.com/classroom>
- Dweck, C. S. (2013). *Self-theories: Their role in motivation, personality, and development*. Psychology press.
- Hiebert, J., & Wearne, D. (2003). Developing understanding through problem solving. *Teaching mathematics through problem solving: Grades 6-12*, 3-14.
- Mathematical Association of America. (2018). *MAA instructional practices guide* [PDF]. https://maa.org/wp-content/uploads/2024/06/InstructPracGuide_web.pdf
- Patel, M., Aitken, D., Xue, Y., Sockalingam, S., & Simpson, A. (2021). An evaluation of cascading mentorship as advocacy training in undergraduate medical education. *BMC Medical Education*, 21(1), 65. <https://doi.org/10.1186/s12909-021-02489-y>
- Ramani, S., Mann, K., Taylor, D., & Thampy, H. (2016). Residents as teachers: Near peer learning in clinical work settings: AMEE Guide No. 106. *Medical teacher*, 38(7), 642-655. <https://doi.org/10.3109/0142159X.2016.1147540>
- Seery, C., Andres, A., Moore-Cherry, N., & O'Sullivan, S. (2021). Students as partners in peer mentoring: Expectations, experiences and emotions. *Innovative Higher Education*, 46(6), 663-681. <https://doi.org/10.1007/s10755-021-09556-8>
- Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological science*, 29(4), 549-571. <https://doi.org/10.1177/0956797617739704>
- Tripathy, S. T., Kershaw, T. C., Chandra, K., Thompson, C., Allen, J. A., Denis, M., ... & Yu, T. (2022, June). Engaging Graduate Students as Co-creators of Educational Modules on an Interdisciplinary Topic. In *Proceedings of the 2022 ASEE Annual Conference & Exposition*. Retrieved from <https://par.nsf.gov/biblio/10427469>
- Wiggins, G. P., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Pearson.