

Education Notes brings mathematical and educational ideas forth to the CMS readership in a manner that promotes discussion of relevant topics including research, activities, and noteworthy news items. Comments, suggestions, and submissions are welcome.

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Notes pédagogiques présentent des sujets mathématiques et des articles sur l'éducation aux lecteurs de la SMC dans un format qui favorise les discussions sur différents thèmes, dont la recherche, les activités et les nouvelles d'intérêt. Vos commentaires, suggestions et propositions sont le bienvenue.

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This issue of Education Notes features a contribution concerning first year mathematics, or so called level 1 courses. One of the focal points of attention for Education Notes in upcoming issues is the matter of first year mathematics at the tertiary level. The editors welcome your comments, contributions, and ideas concerning this matter. Veselin Jungic and Miroslav Lovric offer an opening to the discussion including an update on some upcoming initiatives to bring people together around this topic.

Call for National Dialogue: The Present and Future of Teaching First Year Mathematics at Canadian Universities

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Canada's university mathematical teaching community is facing a number of significant challenges and opportunities. These range from managing increasingly diverse classes of incoming students, to understanding and addressing the impact of modern technology on teaching and delivering courses, to keeping course content relevant for various academic programs and, most importantly, to effectively supporting students to achieve their personal, academic and career goals.

To our knowledge, there is no source of any kind which provides a comprehensive picture of the current state of teaching mathematics at the first-year undergraduate level in Canada. We believe that only by sharing experiences, gathering data, and looking at research-based decisions and strategies, our mathematical teaching community can come up with ideas and suggestions for university faculty and instructors to move forward.

Hence this note. Its main purpose is to initiate a national dialogue, focused on the following themes and questions:

- Teaching level 1 math courses in Canada: What is common, what is different, and what are the driving forces behind the current situation?
 - » Horizontal perspective - comparison of goals and practices at different universities
 - » Vertical perspective - comparison of goals and practices at the high school and university levels

- » Cross-cutting perspective - examination of the roles that level 1 math courses play in various academic programs

- How can we create a set of level 1 math courses that keep the necessary mathematical rigour; are accessible to a wide range of students; are relevant for a spectrum of academic programs; and are general and flexible enough to allow mobility across different programs, institutions, provinces and countries?
- What else, if anything, beyond math content should be done in level 1 math courses?

Context

Every year, for tens of thousands of first-year university students across Canada, taking a math course, most often calculus, is one of their first university academic experiences. Serving as both a gatekeeper and a requirement for programs ranging from economics to science to engineering, first year math courses come with numerous challenges for students, instructors, mathematics departments, university administrators, and academic programs.

A large number of entry-level university students are going through a bumpy transition, commonly referred to as the *secondary to tertiary transition*. Taking a fast-paced, topic-packed first-year math course that is often taught under the assumption that students more or less know all of high school mathematics presents significant challenges, and a good number of students cannot successfully meet the demands such courses, and their instructors, place on them.

An instructor teaching a first-year math course faces two seemingly contradictory tasks. On the one hand, they have a responsibility to teach the course at the appropriate level of rigour, making sure that all topics, as mandated by the university calendar, are covered. On the other hand, the course instructor plays an important role in welcoming, encouraging, and supporting students during one of the major transitions in their lives. Instructors are also expected to keep up with teaching and learning technologies: from handling ever-evolving learning management systems, to creating electronic learning resources, to using in-class technology for delivering or

enhancing their lectures, to facing competition from a variety of freely available online resources.

For administrators, there are different kinds of challenges. After working hard to enroll students into their programs, they see students' hardships in math courses as one of the major factors that contributes to dropout rates. A further challenge is managing a large number of students taking math courses. This may include choosing between teaching a course in large classrooms and teaching multiple smaller sections; these decisions are often based on factors that have nothing to do with pedagogy.

Mathematics departments are forced to reassess the content of their courses and academic programs. This includes modifying existing, and/or creating new courses that address the needs of various (new) programs. For example, a computer science program may request an introductory discrete math course; a school of interactive arts may prefer a course that offers a brief introduction to geometry and linear algebra; or an economics program may choose an introductory game theory, or data analysis course. Moreover, there are academic units that are creating and teaching their own "math" courses, claiming that mathematicians do not have expertise to address, in the ways they see as adequate, mathematical aspects of their particular fields.

Still, the most important set of questions is the same as it has always been: To what degree do university math courses realistically contribute to developing students' problem solving and analytical skills; to increasing their awareness about the role that mathematics and numeracy play (and will continue to play) in both their private and professional lives; to further expanding students' intellectual and academic capabilities; and to widening students' carrier options?

Rationale

Our consultations with colleagues have confirmed our belief that, with some variations, the situation described above is common at universities across Canada. At the same time, there is an array of approaches and practices, at the provincial and institutional levels, addressing the same set of issues. The fact that level 1 math courses are *the* common factor for a number of university programs across the world suggests that the successful completion of these courses contributes to educating students to become global (academic) citizens.

The sequence presented in the previous paragraph

*identical/similar set of issues →
array of approaches → global/broad impact*

in our opinion, requires a national dialogue about the present and future of teaching mathematics at Canadian universities.

We would like to underline the urgency for a national dialogue about teaching mathematics by stating that, to safely and responsibly navigate through our increasingly big-data-driven world, every Canadian citizen will need *deeper* knowledge and understanding of

various mathematical aspects of the reality and an enhanced and probably highly personalized mathematical toolkit.

Goals

We envision this proposed national dialogue as part of a longer-term project, during which data about level 1 mathematics courses offered at Canadian universities will be collected, organized and disseminated. It is our belief that the project will unite Canadian teaching and research faculty in their efforts to provide the best post-secondary math education possible, and will provide a forum for all involved to learn about the complexity of issues related to teaching level 1 mathematics at universities across Canada.

Collecting data: In addition to creating a comprehensive list of level 1 courses offered at Canadian universities, we see a need to establish how these courses are interconnected with other courses:

- *Vertically:* To what degree, and how, is the structure of level 1 math courses driven by current high school math curricula? How strictly is the content of level 1 math courses determined by the requirements of higher level courses? What fraction/how many of all level 1 math courses are terminal?
- *Horizontally:* How do level 1 math courses compare across Canadian post-secondary institutions, in terms of overall structure, modes of instruction, and content?
- *Across:* What are the roles that level 1 math courses play in various academic programs?

Community: The national dialogue will present an opportunity for Canadian university math instructors to share their experiences about developing and teaching introductory math courses with their peers. We invite mathematics faculty at all levels and across the pure-applied divide, including department chairs and faculty in charge of undergraduate teaching, to join the dialogue.

Learning and Solutions: The dialogue will be an open forum in which participants will discuss existing and upcoming challenges in teaching mathematics at this level and search for possible strategies to meet those challenges. The authors of this note are convinced that this kind of critical exchange of information, opinions, and practices will lead to a joint action and thus benefit all involved, their institutions and students, and Canadian society more broadly.

Means

We envision *National Dialogue: The Present and Future of Teaching First Year Mathematics at Canadian Universities* as a grass roots movement that will involve faculty, including adjunct faculty, departments, the regional institutes (AARMS, CRM, Fields, ISM, and PIMS) and relevant pan-Canadian groups and societies (CAIMS, CMESG, and CMS). The dialogue would take different forms, from informal meetings of a group of colleagues from the same department to discussions and exchanges of ideas over social media, and from conducting surveys and writing academic papers to regional and national workshops and conferences.

Two significant events that will affect the present and future of first year math courses at Canadian universities are scheduled in the next several months. Malgorzata Dubiel from Simon Fraser University and Kseniya Garaschuk from the University of the Fraser Valley will organize an education session at the 2017 CMS Winter Meeting, (Waterloo, ON, December 8-11, 2017). The session will be titled *Rethinking first year experience*. The authors of this note are the co-organizers of the Fields Institute's sponsored conference *First Year University Mathematics Across Canada: Facts, Community and Vision*. This conference is scheduled for April 27-29, 2018, in Toronto, ON.

We see the CMS education session and the conference at Fields as the beginning of a sequence of events that will strengthen the community of Canadian university math instructors around our common goal: to develop and teach math courses relevant to our times; to future academic programs; and, most importantly, to our students.

Follow-up events (conferences, workshops, online and local discussions) will further the agenda by investigating pedagogical approaches that support teaching (modified, or potentially new) mathematics courses at level 1, as well as finding ways to provide opportunities for an increasingly diverse student body to succeed in math courses. This will, for example, include a search for balance between the use of technology in teaching mathematics and face-to-face in-class and out-of-class student-instructor interaction.

We are aware that we are addressing a global problem that has only local and short-term solutions, due to diverse and evolving circumstances. Still, those local solutions, that by the nature of things, may substantially differ from institution to institution and from province to province, will share many common elements. Those elements include overlapping sets of constraints and the same desired outcome of creating a learning environment that enables students to further explore and develop their mathematical talents and skills.

Therefore, we do not think about this national dialogue as a limited project that ends up with some kind of final report containing a list of recipes. Quite opposite: we see the national dialogue about level 1 math courses as an outgoing process that will, as part of strengthening our community, create a sharable dynamic online repository. This repository will contain extensive data about level 1 math courses offered at Canadian post-secondary institutions; informal descriptions of various practices in teaching level 1 math courses and instructors' reflections about their experiences; a searchable list of academic publications on related topics; and summaries of discussions and meetings.

Conclusion

It is the responsibility of mathematical community to keep iterating that current and future developments of Canadian and global societies are connected to advances in mathematics.

Traditionally, first-year math courses represent one of the strongest links between secondary and post-secondary education. A lack of success in high school mathematics probably means that a student's academic options are significantly narrowed or that the student would need additional investment of money, time, and effort to bring their mathematical knowledge to the required level. For those students who take a first-year math course, the course may act as a railroad switch, either keeping them on the intended direction or diverting them towards another academic program. For many students, first-year university math courses are their first real opportunity to discover and explore their mathematical talents and interests.

Therefore, first-year math courses present unique opportunities and challenges to substantially influence Canadian students regarding their attitude towards, and knowledge and significance of mathematics. To use this opportunity and meet the challenge in this fast-changing academic world, all of us who teach, or are otherwise involved in post-secondary math courses in Canada have to communicate, share our experiences, coordinate our efforts, and work together.

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