Teaching First Year Mathematics Courses: Past, Present, and Future

Andie Burazin (UTM),
Lauren DeDieu (Calgary),
Veselin Jungic (SFU),
Miroslav Lovric (McMaster)

7-12 August 2022

1 Introduction

The "Teaching First-year University Mathematics Courses: Past, Present, and Future" workshop has been planned as a major event in the ongoing discussions about teaching first-year university mathematics and statistics in Canada and beyond.

In recent years, discussions centred around teaching first-year mathematics have been held in Europe, Australia, Canada, and the United States. The topics examined have ranged from managing increasingly diverse classes of incoming students, to keeping up with students' shifting beliefs and attitudes toward mathematics and learning mathematics, to teaching hybrid and online courses, to understanding and addressing the effects 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.

Despite a history of criticism and numerous calls for changes, calculus still heavily dominates first-year university curricula, creating a bias that is hard to minimize. Often taught in a traditional lecture format in large classrooms or online, with a focus on routines and algorithms, and with very little or no reference to genuine, true-life applications, calculus instruction paints a picture that further alienates students (and the general public) from mathematics.

A large number of entry-level university students are going through a bumpy transition, commonly referred to as the secondary to tertiary transition. Taking fast-paced, topic-packed courses that are taught under the assumption that students more or less know all of high school mathematics is difficult, and a good number of students cannot immediately overcome the challenges they face. We do not know much about what our students in the 2020s are like, and how modern technologies, in particular social networks, affect their beliefs, views, and attitudes toward learning mathematics. Furthermore, we are in the dark about likely negative impacts of the prolonged absence of the face-to-face student to instructor, and peer to peer interactions.

The current status and the future of the university mathematics courses and programs are of the concern of the governments, professional societies, academic institutions, as well as individual instructors. Our American colleagues summarized it in the most succinct way: "The status quo is unacceptable" (Executive summary, page I, in Saxe, K. and Brady, L. (2015). A Common Vision for Undergraduate Mathematics Sciences programs in 2025. *The Mathematical Association of America*). In Australia, the First Year in Maths (https://fyimaths.org.au/) network "was established as part of a project funded by the Australian government Officer for Learning and Teaching from 2012-2014" to address concerns about mathematics instruction. In Canada, attempts (successful!) to initiate a national dialogue about the first-year university mathematics courses have been largely grassroots. (Further details about the recent first-year mathematics teaching initiatives in Australia, Canada, and the USA are presented in the paper: Burazin, A., Jungić, V., and Lovrić, M. (2020). Three Countries, Two Continents: Common Challenges and Opportunities in Teaching First-Year Mathematics, *Notices of the American Mathematical* , Volume 67, No. 1, pages 64-67.)

Over the last few years, the co-applicants on this proposal have been involved in several pan-Canadian initiatives related to teaching first-year mathematics and statistics courses. These initiatives include the creation of an online course repository, multiple conferences and workshops, online meet-ups and seminars, and a newsletter. In our view, the main outcome has been the emergence of a vibrant, coast-to-coast community of academics concerned about teaching mathematics at the post-secondary level. These personal and professional connections among the members of the Canadian post-secondary mathematics and statistics teaching community were crucial for the community's reaction to the crisis caused by the Covid-19 pandemic. Since March 2020, we have witnessed exceptionally high levels of collaboration among our colleagues, ranging from sharing experiences and ideas to working together on mathematics education research-related projects, to co-organizing national events about math education.

The workshop in Kelowna was an opportunity to re-evaluate Canadian mathematics teaching community's actions and activities during the pandemic and (hopefully) post-pandemic, to summarize the outcomes, and, most important, to objectively assess the current status and the future of teaching of mathematics at the university level.

We are curious and concerned about how the current disruption of our academic and personal lives will affect, or amplify, some of the previously observed weak spots in teaching mathematics. We illustrate these concerns using a somewhat surprising outcome of the "First Year University Mathematics Across Canada: Facts, Community and Vision" conference hosted by the Fields Institute in Toronto in April 2018. Through the group discussions and by analyzing data in our courses repository, it became apparent how wide the gap between "big" and "small" universities is. In other words, mathematics instructors across Canada (and the world) face an overlapping set of issues, as mentioned above, but the environment that they work in, the available resources, and the institutional support may (and do) greatly vary from institution to institution.

The workshop is envisioned as a timely and crucial step for the mathematics and statistics community to address unique opportunities and challenges that teaching first-year mathematics and statistics courses has been presently facing. To ensure success, all of us who teach or are otherwise involved in post-secondary mathematics and statistics courses have to communicate, share experiences, coordinate efforts, and work together.

2 Objectives

The main objective of this workshop has been to generate specific suggestions for possible large-scale modifications in teaching mathematics and statistics at a first-year undergraduate level in Canadian universities, based, in part, on the experience and lessons learned since the start of the COVID-19 pandemic in March 2020.

The university mathematical teaching community is facing numerous challenges. Ranging from managing increasingly diverse classes of students, to understanding and addressing the impacts of modern technology on content and course instruction, to ensuring the continuity of teaching and learning in the pandemic and post-pandemic times, to maintaining the purpose and integrity of assessment, to keeping course content relevant for various academic programs and, most important, to effectively supporting students to achieve their personal, academic and career goals in this ever-changing world, these challenges are particularly pronounced at the university entry level mathematics courses.

The reality of the COVID-19 pandemic placed teaching online at the forefront, and any conversation about teaching must be inclusive of the issues and challenges that have surfaced since March 2020. Academic community hopes to "get back to normal," but what will that "normal" look like? By teaching online, we have created (and will create) thousands of hours of videos and terabytes of online materials – are we going to abandon these resources once the pandemic is over, or incorporate some (how?) into our teaching practice? What are valuable, far-reaching lessons that we learned while teaching during the pandemic?

In March 2020, we found ourselves in what can be described as a transient phase (i.e., a phase of uncertainty), where we were asked to move our courses online, literally overnight, and with no solid guidance or personal experience. We are moving toward the next phase - learning phase - where we share our experiences, critically analyze our teaching, and systematize newly gained knowledge and know-how. Following the learning phase - and this has been the theme of our workshop - is the growth phase, where we build on the outcomes of the learning phase, plan for, and implement changes in the ways we teach first-year mathematics in university.

With these thoughts and facts in mind, we will look to the future. Our objective is to collectively generate specific suggestions for possible large-scale modifications in teaching mathematics and statistics at a first-year undergraduate level in our universities. The following themes, each discussed during one day, guided all workshop activities:

(1) Monday: Teaching math in 2030. What will course delivery look like in 2030? It is easy to claim that, based on the COVID-19 experiences, it will be some kind of a hybrid - but what would that look like? How do we find a framework/strategy that would provide a good balance between the face-to-face and the online components of learning and teaching? How to best address the rising needs for teacher-training of math instructors, and faculty in general, as this is an essential component of any effective change?

(2) Tuesday: First-year math courses in 2030. What first-year courses should we/will we teach in 2030? Alternative avenues into university mathematics, to reflect the realities of the times we live in, as well as the diversity of students' interests and goals. We investigate what our colleagues in North America, Europe, and elsewhere, plan to do. Increase the breadth of mathematics offerings/ entry points at a first-year level; for instance, future teachers need courses that are different from those taken by future scientists, or those taken by mathematics and statistics majors. As well, consider multiple exit points, to facilitate students' future plans

(3) Wednesday: Our students in 2030. How can we best respond to the constantly changing qualities of incoming university students? What are these qualities? Students come to university for different reasons, but mostly to enhance their "market value" i.e., employability. However, instructors often believe that their students are there because they like the discipline and are willing to learn. How to reconcile this seeming contradiction/ tension? High school mathematics teachers face significant challenges in meeting learning outcomes of the courses they teach. It is highly probable that, as a collateral damage and for many years, teaching of mathematics at the post-secondary level will be negatively affected by the fact that the incoming students will need even more time and effort to bring their mathematical knowledge and skills to a required/desired level.

(4) Thursday: Math curriculum in 2030. Re-think the organization of mathematics curriculum; consider organizing it around big ideas in mathematics, and develop important skills such as problem solving, logical reasoning and proof construction, and communication of mathematical ideas. This is closely related to the emerging pandemic and post-pandemic realities. There is no doubt that the knowledge of mathematics (mathematical modelling, as well as applications

of the outcomes of emerging research in pure mathematics), will be even more dominant as a necessary condition for a range of employment opportunities. How do we prepare our students for that kind of world?

3 Workshop Organization and Participants

We did not have plenary speakers nor long lists of talks; instead, we selected lecturers and topics based on the specific workshop objectives for Monday-Thursday. Following each of these lectures, there was a lengthy discussion (this was one of the rare workshops where more time is allocated to Q&A than to the actual presentation!). Borrowing from successful strategies employed at the Canadian Mathematics Education Study Group annual meetings, a significant part of the workshop was based on working groups, tasked with specific goals. Each working group was assigned a pair of leaders and a note-taker, and was asked to produce a report, to be presented on the last day (Friday) of the workshop. The summary of the working group activity is presented in a separate section.

This workshop demanded active participation from everyone involved. As well, continuing the tradition of the BIRS workshops, we planned for ample time for creative socializing and informal conversations, as often our best ideas emerge from informal, unforced, and casual social time.

Thirty-seven workshop participants came from eight Canadian provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia) and two U.S. states (Michigan and California). Twenty of the participants were female and seventeen were male. We also had a few late cancellations (McCallum, University of Arizona; Khoury, University of Ottawa). The group included some of the world leading researchers in post-secondary math education (Chapman, University of Calgary; Mesa, University of Michigan; Rassmunsen, San Diego State University), some of the already established leaders of the Canadian community of practice (Burazin, University of Toronto Mississauga; DeDieu, University of Calgary), Indigeneous scholars (Doolittle, First Nations University of Canada; Desaulniers, University of Alberta; Causley, McGill University), math faculty holding leading teaching relevant administrative position at their institutions (Fok, University of British Columbia; Hamilton, Mount Allison University; Bouchard, University of Alberta; Desjardins, University of Ottawa), some of the most charismatic Canadian post secondary mathematics instructors (Lovric, McMaster University; Lagu, Mount Royal University; Matthews, Quest University), some of the rising stars of the Canadian teaching community (Boroushaki, Thompson Rivers University; Chow, York University; Ezzat, Cape Breton University; Mosunov, University of Waterloo; Sodhi, Dalhousie University; Sergent, York University), some of the colleagues whose innovations in the curriculum and/or use of learning technologies have changed Canadian math teaching landscape (Fitzpatrcik, Lethbridge University; Walls, University of British Columbia; Davidson, University of Manitoba), graduate students (Mulberry, Simon Fraser University;

Paton, University of British Columbia; Singh, University of British Columbia Okanagan), and many frontline mathematics and statistics instructors with the wide range of teaching experiences (Alderson, University of New Brusnwick; Archibald, Lethbridge University; Duff, Ontario Tech University; Ge, University of British Columbia Okanagan; Han, University of British Columbia Okanagan; Jungic, Simon Fraser University; Postnikoff, University of Saskatchewan; Smith, University of Calgary; Webb, Selkirk College; Yamin, University of British Columbia Okanagan).

4 Novelty of this workshop

To our knowledge there have not been similar workshops in Canada, for many years. A usual venue for mathematics education, CMS education meeting, is limited by the format and does not offer a sufficient amount of time to be spent on a particular topic, nor is there a venue for longer, meaningful interactions between participants. The five days of the workshop offered ample opportunities to creatively socialize, discuss and exchange ideas, collaborate, and in general turn teaching mathematics upside down. Each participant left the workshop with something new, useful and inspiring.

The "Teaching First-year University Mathematics and Statistics in Canada" is a new, pan-Canadian grass roots movement, started in 2017, whose goals are to examine, critically and in depth, teaching and learning of math and stats in Canada, and advocate for change, both at course and curricular levels. A large number of mathematics instructors and faculty participate in the activities, conferences, and workshops, and have connected through this movement. The workshop will help further the goals of this newly formed movement.

As this was a meeting of teaching practitioners and researchers in teaching practice (both Canadian and international), the workshop bridged a well-known gap between the mathematics education community and teaching practice community (the best evidence is that, presently, there are only a handful of people in Canada who belong to both communities). This is a novelty, rarely seen in any mathematics education conference or meeting.

5 Summary of Working Group Outcomes

Working Group 1: Calculus is here to stay - what to teach, how to teach?

Discussion prompt: Is there a need to modify its content, or to change what is emphasized in it? Can we envision (is it needed?) routine use of computing technology in teaching calculus. One calculus, or various flavours. My dream calculus course, my nightmare calculus course. Training of a future calculus instructor.

In order to see how calculus will continue on forever within post-secondary, the 'Calculus is here to stay' working group shared what their nightmare calculus course and their dream calculus course were. This exercise helped the group come up with a more hopeful realistic offering of a calculus course in 2030.

The working group envisioned the nightmare calculus course as follows. Only privileged students had access to calculus, ones that could afford to go to post-secondary. Lecture sections would host 500+ students with no tutorials or labs for support, which means no teaching assistants. Students would purchase expensive NFT textbooks with a subscription to assess practice questions. A course coordinator would run the calculus course and be a dictator where the teaching team would be uncooperative and unprofessional. During lecture, there would be limited technology and only the instructors speaking. Assessments would all be multiple-choice questions. As a result, the status quo remains.

In terms of the course itself, more content would be added with less time to absorb and learn the material. This would lead to a disconnect to the level of prior knowledge required for student success as there is no opportunity to learn missing concepts and ideas. The major of the course would focus on techniques such as integration and ridiculously long algorithmic and computational problems. The worst would be if these techniques and computations were completely done by technology without understanding the theory.

But the worst nightmare for a calculus course would be that mathematicians lose the privilege of teaching non-mathematicians. This could happen in two ways: either no math course required for S and T of STEM, or each non-math discipline teaches their own version of a math course.

Now, the dream calculus course was envisioned by blue-sky thinking and turned out to be very different from the nightmare. Any faculty wants to and is excited to teach the course, where there is pedagogical autonomy and robust professional development. Students are motivated and engaged with the material and in turn help change and shape the course for future offerings. Faculty try to reach the needs of the students' diverse backgrounds and goals. An overall sense of mutual trust is between instructors and students.

Some aspects of the dream calculus course are: an open source, free, well-written textbook (i.e., Apex, Active Calculus); resources to implement practices supported by (accessible) education research; inclusive learning space that support student participation; and small class sizes. When possible, technology would be used to create online/virtual experiences as good as in-person. Government funds would be available for STEM education and ways to obtain reliable data to assess teaching and learning innovations.

The working group knew that the dream course would not be possible by 2030 or even in the future, but it did guide on how to implement attainable changes in the short term. Instructors can shift from publisher textbooks to open and free textbooks. Technology is used to improve both teaching and learning. Streamline content to avoid ridiculous and tedious computational problems and techniques and to have more active learning, authentic applications, and problem-solving.

One possible way to improve the various calculus offerings in a post-secondary institution is to follow the UBC's model: a large lecture system taught for 2-hours by a rock star instructor followed by small tutorials which are split by discipline to focus on applications.

Lastly, the working group has advocated for instructors to facilitate communities of practice. Instructors can join First-year Math and Stats in Canada (FYMSiC), Canadian Mathematical Society, high school teacher dialogues, local teaching and learning centres, and other math education conferences and workshops to learn from others. For the change to happen, the conversation has to continue beyond the BIRS UBCO five-day workshop.

Working Group 2: If not calculus, then what and how?

Discussion prompt: Discrete mathematics, statistics, mathematics for a general student audience, mathematics for teachers, mathematical modeling with and without calculus, computational mathematics, precalculus. Prerequisites? Full courses vs. multiple learning modules? Training of the future instructors of such courses. Appropriate learning resources.

The if not calculus working group began with a shift in perspective for the first year. Instructors should focus on helping students develop skills instead of teaching specific content. This would invite students to discover what math really is. Calculus, the traditional first-year math course as it is taught now, is too dense to accomplish skills development and to discover what math is, which is the motivation of the working group.

The working group came up with a list of what they would like to see future students learn in a first-year math course that is not calculus. In 2030, students will: employ logical reasoning; ask good (mathematical) questions; develop problem-solving strategies; communicate mathematically; think critically, mathematically, and quantitatively; explore proof versus evidence; identify authentic applications; engage in productive struggle; and develop metacognitive awareness of their learning. Most importantly, the working group wants students to be inspired, have fun, and find joy in learning mathematics. An interesting point was made that the list echoed what the calculus is here to stay working group has mentioned in their findings.

This non-calculus course can be created by picking from suitable content modules from: history of mathematics; logic puzzles; probability; data visualization; voting systems; personal finance; discrete mathematics; linear algebra; number theory; geometry; ethnomathematic; modelling; coding and computing; ethical use of technology; and anything else that one likes just like calculus. Obviously, an instructor cannot pick all of these, but select a few that would fit or are comfortable to teach.

The working group wants everyone to take this math course at their post-secondary institution. Most importantly, the course would have a low-floor high-ceiling approach to be accessible to anyone enrolled. The floor is approximately grade 10 mathematics required, and the ceiling is the topics which allow exploration at many levels.

This math course would be like an introduction to biology and chemistry that most other departments have for their first-year students. A potential draft of the course description for the university calendar was created for this non-calculus first-year math course. See below:

MATH 007 - [Insert amazing title here] Students will develop knowledge, skills, and attributes of mathematics as a human activity. This includes learning and doing mathematics through problem-solving, problem-posing, and exploration in a variety of mathematical and statistical contexts. Throughout this course, students will develop inspiration and joy.

One group member pointed out that the course description has to be attractive enough that senior faculty want to teach such a course and work with first-year students, but also cool enough that students want to take it. These two groups are very diverse in what will cojual them to be drawn to the course. Also, the course description needs to be vague enough so that it mentions the skills and not so much the mathematics being taught – a lot of freedom is needed.

Some titles the BIRS working group participants came up with for this course in order to get student buy in were: Mathematical thinking, Mathematical explorations, Math for humans, Mathematical stories, Math for all, even you

Realistically, the working group looked at if such a course could happen in 2030, and came to the conclusion - 'no'. The only way such a course could exist is if we crowdsource to pool resources, get grants and support from our institutions and beyond, and get course release to develop it.

Working Group 3 - Math students and their instructors experiencing transition from high school to postsecondary.

Discussion prompt: Good, bad and ugly: entrance exams, placement tests. Realistically, what can we expect from students, their families, K-12, universities, various communities and society in general as a meaningful way of supporting the first-year students' learning needs in 2030? Can we tell what those needs will be in 2030? Class sizes in the first-year math courses? Will there be a notion of "first-year" as we know it?

The transition from high school to post-secondary in 2030 working group began by focusing on the question: will first year exist? The group believed that there will be a first year or a transition period, as it might take longer than one year. This transition period possibly will be more flexible and personalized than what has already existed for many decades as a one-size fits all approach.

The group had many reasons as to why mathematics will still be around in universities in the future. Mathematics is an essential tool for analyzing complexity, where mathematical thinking and reasoning deal with some of these complexities which includes deciphering the overload of misinformation out there. As a result, math, in the first year, is useful as a path to the development of critical thinking. There will be a practical and moral need for mathematics, but the teaching may evolve or disappear.

Students will need transition resources to help them succeed in their first-year math courses. The instructors should: meet students where they are at; teach students soft skills; help bridge the knowledge and skills gaps; and demonstrate through action the power of mathematical thinking in making their world a better place. Others within the post-secondary institution should exclusively or primarily provide academic, financial and tech support, but adequate learning spaces that are different from current ones.

The transition resources are attainable according to the working group. Instructors in the classroom should adapt to be moderators and motivators, instead of demonstrators, to help guide students in their undergraduate studies. With this, students will probably need multiple entry and exit points in the learning journey that have courses structured as "take what you want and need" to succeed. But, a collaboration with others at the post-secondary institution such as academic advisors would be needed to best provide the student support. Instructors can clearly identify what knowledge is needed before entering a course, as others would work with the student in selecting what they want and need for their programs.

Mathematics courses should structure the "take what you want and need" model. This will help with those students who wonder "why do I need to take this calculus or math class?" There should be different anchor points where students can spend more time within a course or particular area if they need it, beyond the traditional twelve-week term.

Past conversations about transition have typically focused on the negative aspects and consider ways to smooth the discontinuity. While smoothing is beneficial, the working group believes there is a positive opportunity to leverage the challenge of transition.

Transition is a time of exploring. It affords students an opportunity to reinvent parts of themselves and break out of the old habits that they would like to change. Instructors and others in the post-secondary institution need to support the students in this metamorphosis, whether it is primarily reinvention or reaffirmation. Students need to be aware that the personal transformation during this time is normal and to be expected. Thus, let's strive to leverage the transition gap to help our students reinvent (or reaffirm) themselves as math-friendly citizens.

Working Group 4 - What knowledge and skills will a university math instructor in 2030 need

Discussion prompt: What knowledge and skills will a university math instructor in 2030 need to safely navigate their and their students' well-being in the context of learning mathematics? How to understand, and possibly benefit from, the changes that each new generation brings? Team teaching? What kind of graduate training would be the best to prepare a future first-year math teaching faculty? What expectations will there be from a first-year mathematics instructor - pedagogical, scientific, technological, societal? What will be the role of a teaching faculty in the dynamics between mathematical and educational research: a boundary point that belongs to both or an isolated point?

The knowledge and skills of mathematics instructors' working group began their inquiry with the question: what will teaching look like in 2030? Perhaps artificial intelligence and other technologies will help in the learning of calculus and math, in the same way one learns languages these days. This led to a discussion on whether instructors will be relevant when it comes to learning mathematics in the future. The group has reached the consensus that the instructors are important to provide a framework for the learning within a mathematics course and the WHY (why are we learning this mathematics). The instructor also is needed to assess what the students know, where technology can only go so far with assessment.

If instructors are relevant, the working group explored what instructors need to bring into the classroom. The knowledge and skills that instructors need are: curiosity about teaching; knowledge of teaching and learning (e.g., assessment theory); compassion and empathy towards students; an anarchist approach where actions align with values; transparency with instructor's choices and why things are being learnt; adaptability to situations as the change; and thinking processes.

The working group provided ways of creating support to ensure that an instructor can gain the knowledge and skills. They categorized the support at an individual level and departmental/institutional level. At the individual level, observing other individual's teaching is really valuable to see what you like or dislike about a particular teaching approach or learn about new ideas. However, the working group did note that some individuals might not feel comfortable having their own teaching observed, especially if they are new or trying something different in the classroom, to receive a critique about their teaching. Also, an instructor can sign up for training or a program within or outside (e.g., online course) on EDI, assessment theory, metacognition, and learning theory. Hearing about other experiences or participating in learning projects will help instructors develop their compassion and empathy. From a departmental or institutional level, a systematic mentorship program, which some institutions have but should be more formal and for junior faculty. An instructor who develops their teaching skills should be valued and incentivized to improve the overall student learning experience and quality of courses. As well, departments and institutions should create opportunities for professional growth to continue learning and promote research.

Back to the individual level, instructors can build a community to help others gain skills and knowledge. This could mean having meetings (where food encourages people to show up), starting a book or podcast club, or even reaching out to new faculty. At the next BIRS meeting, organizers can invite experts in teaching and learning to share their ideas with the math and stats teaching community.

Working Group 5 - Horizontal and vertical connections, integration.

Discussion prompt: How do we organize undergraduate math curriculum in 2030? Still as a network of boxes (courses), with prerequisites and antirequisites? Is it possible (or desirable) to organize some of the curriculum around math habits of mind (or another concept that suggests organization different from what we have now? What do level 1 students need to know, and what skills must they have to succeed in level 2 courses? How to ease the transition from level 2 to level 3 math courses?

The horizontal and vertical connections and integration working group started with a motivating idea from the knowledge and skills of mathematics instructors' working group: focus on the process of thinking mathematically rather than the product of mathematical thought.

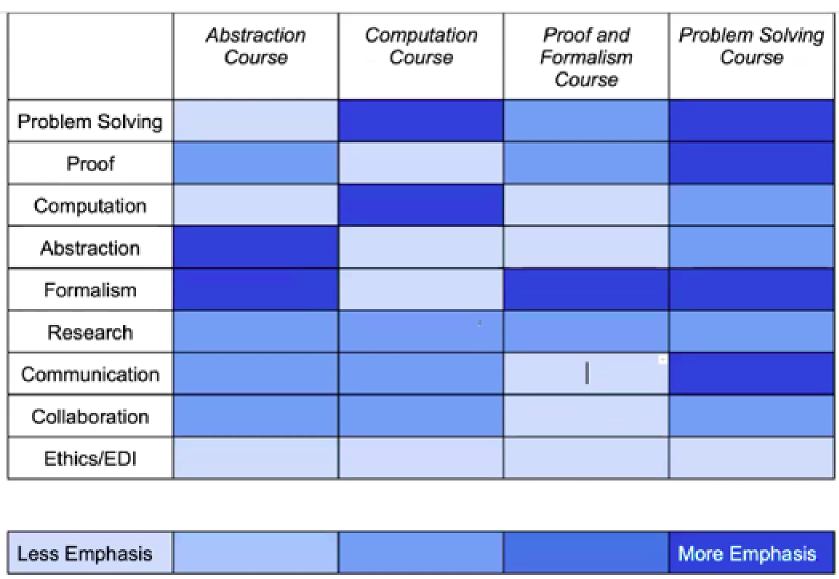
A lot of students often ask instructors: why is mathematics valuable? And instructors have a good answer: it teaches for example critical thinking, by that it teaches problem solving, abstraction, computation, and different ways to think about the world. But mathematics is taught in stealth mode, where topics are taught first, and then the skills. In other words, undergraduate mathematics programs are usually designed in terms of topics (i.e., mathematical contexts) such as calculus, linear algebra, and differential equations.

Graduate attributes are treated as secondary outcomes which students hopefully acquire while learning a given topic.

What are graduate attributes? Graduate attributes are skills-based program-level student learning outcomes: problem solving, proof, research computation, abstraction, communication, professionalism/ethics/EDI, formalism, and collaboration.

The proposal of this working group was that the course curriculum should be based on graduate attributes as the driving force of what we teach. The graduate attributes should guide our curriculum independent of context.

The working group designed a courses plan in a mini-mathematics department:



Students progress through levels I, II, III, and IV in the courses described above. Each level has the same learning goals, but with increased mathematical complexity within a mathematical context. Each course can be delivered in a specific mathematical context or a combination of context: analysis, algebra, arithmetic, and geometry.

The working group also created an example of a course outline for Abstraction 101, where the learning goals were completely mathematical context independent but focused solely on skills. Obviously, mathematical context will be thought of second, because you cannot just teach skills.

How does a student move through this curriculum? There would be a 101 course for each of the course themes in the table above. But a student might want to do more applied mathematics. In this case, the student would complete the formalism in level 1 and as they progress would receive exposure just more geared toward the student's interest. At level 4, students would have a more research type/"choose your own adventure" type courses where they are tailored to the student's interests and what the student finds more valuable. The emphasis of a student moving through this math curriculum is what the student can do with it rather than the mathematical context being taught.

6 Conclusion

It was our true honour, pleasure, and privilege to witness the talent, dedication, knowledge, and camaraderie that each participant generously and authentically shared with others during our five-day workshop.

We were all very impressed with and enlightened by the working group presentations during our last day together. In our view, as the BIRS workshop group but more like a math family, we really came together and produced some fresh ideas and creative suggestions that will help each of us (except for Veselin and Indy, whose teaching days are nearing their end) with our attempts to serve better our students and our beloved subject in the near future.

Maybe we did not completely resolve or grasp any of the big challenges that are ahead of us, but we surely proved that our profession of teaching post-secondary mathematics and statistics in Canada is in good hands!

We would like to send out a special and warm thanks to Vilma Mesa (Michigan) and Chris Rasmussen (San Diego). Their US experiences and perspectives helped us expand and better understand our own views about teaching mathematics at the first-year level in post-secondary.

In the spirit of diversity, we are happy to report that our BIRS workshop was a pan-Canadian university mathematics related event in which the male participants were in the minority! We are also very proud to share that our group included three Indigenous mathematicians, another indication that the future is not bringing only challenges, but also a positive change.

Our discussions in Kelowna, highlighted our joint hope that our professional and personal transformation during this time of upcoming and already ongoing changes in academia will be positive and beneficial for our students and our beloved profession.

[Working group reports as well as other workshop-related files can be found on the BIRS Workshop site under Workshop Files]