Undergraduate Mathematics Education in 21st Century: Rethinking Curriculum
L'enseignement des mathématiques au premier cycle au 21e siècle : repenser le curriculum

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PANEL DISCUSSION: What is the mathematics we 'should' teach and the pedagogy we 'should' use in this XXIst Century?

Is our undergraduate education in sync with what is needed from us? Does/Should our undergraduate education mostly benefit future academic mathematicians to the expense of the majority of students in our undergraduate courses? Are many mathematics departments destined to become only service departments?

Are we disconnected from the XXIst Century student?

LAURA BROLEY, Université de Montréal

Computer Programming and the Ideal Undergraduate Mathematics Program: Some Mathematicians' Perspectives

A recent survey of Canadian mathematicians points to an astonishing gap between the use of computer programming in mathematics research and postsecondary mathematics education: while 43

This project is conducted as part of a Master's degree in mathematics at Université de Montréal under the co-supervision of France Caron (Département de didactique) and Yvan Saint-Aubin (Département de mathématiques et de statistique).

CARMEN BRUNI, University of British Columbia

The Math Exam/Educational Resources Wiki

The Math Exam/Educational Resources (MER) wiki, founded in 2012 and hosted at

http://wiki.ubc.ca/Science:Math_Exam_Resources

is a digital educational resource for undergraduate students created mainly by a volunteer committee consisting of graduate students at UBC. We will first briefly demonstrate the wiki, its associated mobile application and present usage statistics. In particular, we will talk about how innovative use of MediaWiki technology allowed us to turn what started as an exam database into a year-round interactive study aid. We will then discuss how this online resource has the potential to transform how students engage with undergraduate mathematics. We conclude with a discussion of our current and future directions for research and how we believe that this innovation can change course design and curricula.

CHANTAL BUTEAU, Brock University

Undergraduates Learning Programming for Simulation and Investigation of Mathematics Concepts and Real-World Modelling

The European Mathematical Society (2011) recently stated in a position paper on the European Commission's contributions to European Research: "Together with theory and experimentation, a third pillar of scientific inquiry of complex systems has emerged in the form of a combination of modeling, simulation, optimization and visualization." (p.2).

The Department of Mathematics and Statistics at Brock University adapted its undergraduate program in 2001 in a way that addresses the need mentioned by the EMS. In a sequence of three core mathematics courses, all mathematics majors and future mathematics teachers learn to use computer programming for simulation and investigation of mathematics concepts, conjectures, and real-world modeling. In this presentation, I will discuss the integrated teaching model used at Brock (students learn computer programming within the mathematics courses), including a short report of students' views on the nature of these courses as well as their views on competencies developed (survey study, N=56).

European Mathematical Society (2011), Position Paper of the European Mathematical Society on the European Commission' s Contributions to European Research [online]. Available: http://www.euro-math- soc.eu/files/EMSPosPaper13_03_2011_NP .pdf

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FRÉDÉRIC GOURDEAU, Université Laval

Mathematics, technology and curriculum: a complex interaction

In reflecting about the curriculum as it is being developed and implemented in our university, it is striking that a large proportion of the courses are close to those I attended as an undergraduate in the early eighties. This is mostly true of the standard introductory mathematics courses, less so for the optional ones, and much less so for many of our statistics courses. Where courses differ, it is sometimes only in the way the material is being covered, and sometimes the content itself is very different.

In my presentation, I will present my reflections on the challenges posed by the availability of new technologies for some of our teaching and how we addressed it in some of our courses, including large service courses. I will also share my reflections on some of the differences between mathematics and other sciences which may be relevant for our discussions.

NADIA HARDY, Mathematics and Statistics, Concordia University

1939 – 2014: Can the mathematics undergraduate curriculum catch up? (*)

The typical student who chooses to major in mathematics has in mind either becoming a high school teacher or an actuary. This is a pragmatic career-oriented major; nonetheless, professors often lecture about theory and the beauty of mathematics, and despite the practical values of American society, there are always a small number of students who become fascinated with mathematics. How can we address this diversity in the undergraduate mathematics curriculum/classroom? Whatever the answer to this question is, the purpose, goals and means of undergraduate mathematics education have to acknowledge that in today's rapidly changing technological world, students can never consider themselves fully educated. They must first of all learn how to learn, how to catch up, how to create, so they can deal with (and bring about) the "techno-logical" changes and the methodological, theoretical and societal shifts that often result from them.

(*) The claims in this abstract are, perhaps, no longer true; the abstract itself is the result of paraphrasing mathematics education reports and papers appeared over the last 75 years. I will reveal what was said when at the talk–let's say for now that some essential questions have not changed; they remain unanswered and mostly unaddressed.

MARGO KONDRATIEVA, Memorial University

On the importance of combining new and old mathematical ideas

Addressing the question whether or not "mathematics in 1999 looks like mathematics in 1939" when it comes to its teaching, I discuss situations when I would rather have an affirmative answer. Namely, I prefer to see our students being equipped with some ideas stressed in mathematics curriculum a century ago but diminishing now.

My concern is that many students graduating from universities today are familiar with formal algorithmic procedures to solve mathematical problems while they are often unable to explain and justify them or connect them to more intuitive constructions because the students were never exposed to these ideas.

I give examples illustrating that some old, elementary, yet insightful mathematical methods and facts remain effectively concealed from students studying mathematics today. I argue that while it is important for students to know modern approaches, their education should also include experiences highlighting preceding ideas related to these advanced methods. Building on a proper combination of modern and old ideas is essential for students to develop flexible thinking and use mathematics for modeling real life phenomena. Otherwise, they will tend to stick to procedural techniques and will not fully appreciate the results of modern approaches because of lost connections to old but enlightening mathematics.

MIROSLAV LOVRIC AND CHANTAL BUTEAU,
Undergraduate Mathematics Education in 21st Century — Rethinking Curriculum : Introduction

Despite the rapid changes of communication, technology and information, Hillel (2002), reporting on the Working Group on "Trends in Curriculum" at the 1999 ICMI Study on Teaching and Learning of Mathematics at the University Level states:

"A fairly accurate picture of undergraduate mathematics is that, by and large, it is still dominated by the 'chalk-and-talk' paradigm, a careful linear ordering of course content, and assessment that is heavily based on final examination. Even the highly publicized 'computer revolution' has not really made a sweeping impact on mathematics. ... That said mathematics in 1999 looks a lot more like mathematics in 1939 than is the case with any of its sister sciences." (p.64)

Furthermore, Hillel (2002) adds that, "Steen has written that 'strong departments find that they replace or change significantly half of their courses approximately once a decade' and 'as new mathematics is continually created, so mathematics courses must be continually renewed' (Steen 1992). These on-going updates to the curriculum can be regarded, in a sense, as 'deterministic' aspects of curriculum change, ones that do not put into question the purpose, goals, and means of undergraduate education." (p. 61)

In this mathematics education session, we will reflect and criticize on the present-day university curricula and think about possible directions for the near future.

Hillel, J. (2002). "Trends in curriculum" in The Teaching and Learning of Mathematics at University Level, D. Holton, Ed. Springer Netherlands, pp. 59-69.

AMI MAMOLO, University of Ontario Institute of Technology
An argument for the unconventional in undergraduate mathematics education

This presentation reports on research from several studies which attend to undergraduate students' mathematical argumentation, reasoning, and value judgments. Some of the questions explored include: What do mathematics majors consider when interpreting the validity of an argument? What underlies their choices when deciding on a particular strategy or approach? and, How may such research inform instructional practice at the undergraduate level? An argument is made in favour of the unconventional, both as a lens through which to understand mathematics learning and as means through which mathematics learning may be fostered.

ASHLEY NAHORNICK,
Is Calculus Really Necessary

Mathematics is more than formulas and numbers, but how can we make non-math majors appreciate this? In this talk, I will describe a potential alternative to Calculus, a general problem solving course.

Most first year students in Natural Sciences, Business and Education are required to take Calculus. For many of them, Calculus seems unrelated to their career ambitions. So, we must really ask ourselves, are there other potential avenues to get students thinking, investigating and problem solving in mathematics?

I will suggest course content, structure and objectives of a potential problem solving course. The course I am suggesting would be targeted to non-math majors and focus on solving problems strategies, frameworks and practice of open ended non-routine problems. I will also detail universities in Ontario that offer similar courses.

ANDREY NOVOSELTSEV, University of Alberta
Reflections on Increasing Use of Software in Teaching Mathematical Optimization

We reflect on changes made to the teaching of Mathematical Optimization/Linear Programming at the University of Alberta during 5 consecutive course sections in 2011-2014 . Starting with a "computer-agnostic" approach (used course notes specifically reassured students that "programming" in the course title has nothing to do with computers), a module was developed for Sage CAS that allowed "manual" performance of most of the high-level steps of the simplex method, while numerous underlying arithmetic operations were quickly (and accurately!) done by a computer. This module was recommended to students for use in their homework and then made mandatory both for homework assignments and examinations. Of course, it was necessary to redesign questions given to students, not only because problems "suitable for hand work" are too easy when using computers, but also due to ease of copying electronic documents. It also suggested changes to the topics that can/should be covered in the course as well as to the prerequisites that would be useful to have.

DAVID POOLE, Trent University
Flattening the Mathematics Curriculum

The structure of the standard North American university mathematics curriculum has not changed substantially in the past fifty years, if not longer. For mathematics majors, the required introductory course is almost universally calculus and the entire curriculum is cumulative in nature. Viewed as a tree, it is narrow at the base and bushy at the top where the most mathematically-rich courses are found. In this talk, I will discuss ways in which the curriculum can be "flattened" to provide multiple pathways into mathematics for a variety of audiences. A flatter curriculum also allows rich mathematical topics to be introduced earlier than in a conventional curriculum. There is also the potential for interesting linkages with other disciplines.

CHESTER WEATHERBY, Wilfrid Laurier University
Underprepared for first year Mathematics: Now what?

There is a growing concern about a continuing decline in mathematics achievement and the current and future participation in STEM-based disciplines and careers. International standardized tests are showing many countries, including Canada and the US, lagging behind in terms of mathematics achievement across youth and adults. Studies from the US suggest that many students studying post-secondary mathematics are at least two levels behind in their readiness to engage with the content (Strother, Campen, and Grunow, 2013). Many students are simply not prepared for first-year mathematics classes when they arrive on campus. We will present some findings from a cross-institutional analysis of practices of 31 Departments of Mathematics across Canada. In our presentation we will look at efforts aimed at promoting student success through remediation, streaming procedures, integrated and engaged learning, retention and recruitment. We will also discuss updated pedagogies in (and out of) the post-secondary mathematics classroom which are being implemented and tested as part of a larger statistical analysis aimed at quantifying the impact of adopting new teaching methods to help fill the gap for these struggling students. Implications for future research in the field will also be discussed. This is joint work with Donna Kotsopoulos and Doug Woolford.

Reference:

Strother, S., Campen, J. V., and Grunow, A. (2013). Community college pathways: 2011-2012 Descriptive report. Retrieved December 1, 2013. from http://www.carnegiefoundation.org/sites/default/files/CCP_Descriptive_Report_Year_1.pdf.

WALTER WHITELEY, York University
Spatial Reasoning and Communication: Core Mathematics Curriculum

Many areas of human reasoning, particularly of applications of mathematics in engineering and science, as well as core problems in mathematics depend on solving problems embedded in space. Human reasoning to solve these problems (including setting up the computer programs that are part of the solutions), as well as communication across disciplines working on shared problems, depends on spatial reasoning. Studies show that many students emerge from our high schools weak and uncertain in spatial reasoning. In Engineering there are programs for first year students to develop spatial reasoning – programs which have demonstrated improved performance and improved retention, further demonstrating that spatial reasoning is learnable at all ages. There are reasons to provide programs to develop spatial reasoning for first year mathematics students, and for graduating mathematics teachers. I am currently developing such modules for use at York University. For the 21st century, we must either provide such supports in first year, or ensure students enter with strength in spatial reasoning and continue to develop their spatial reasoning.